PRAGMADEV
real time development tools

Real Time Developer Studio

User Manual

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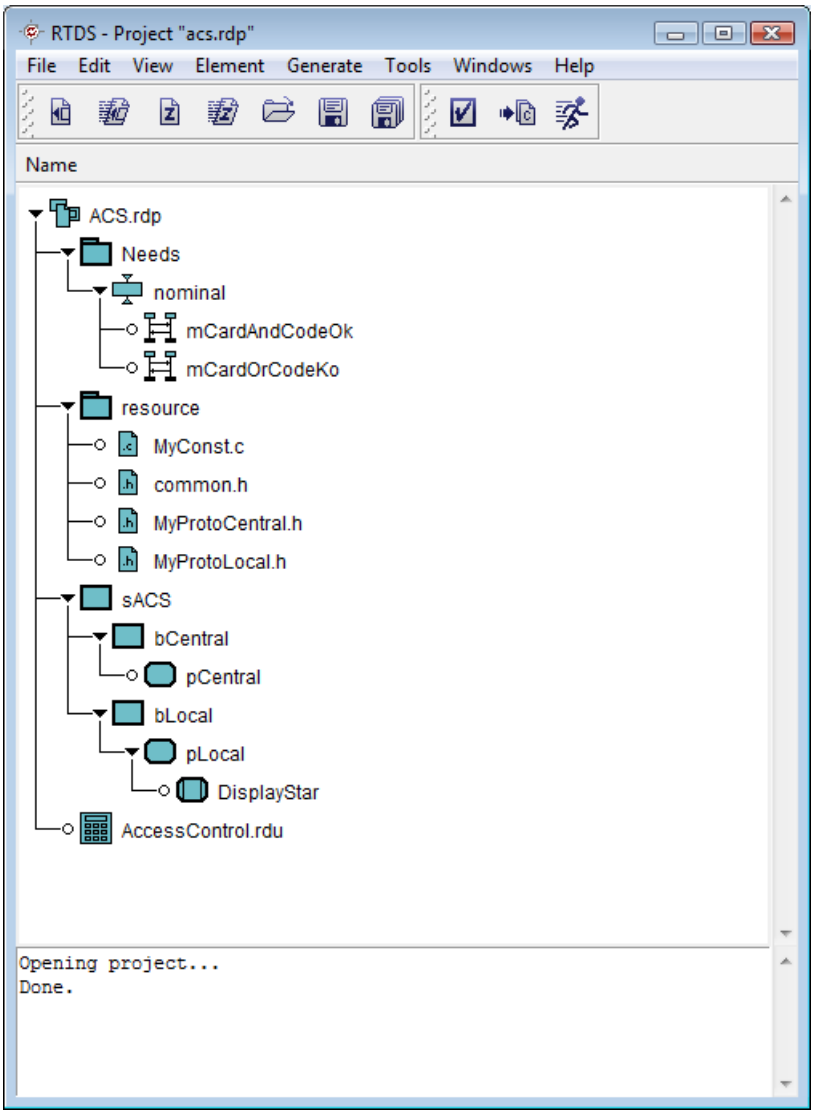
1 - Project manager

The project manager window is the main window of the application. It's the first window that appears when you run Real Time Developer Studio, and closing this window quits the application.



Project manager window

1.1 - Project

A *project* is the set of all needed files necessary to build your system. A project may include files of many types, as described in "Supported file types" on page 9.

A project is arranged in a tree. For SDL-RT or SDL diagrams, this tree represents the hierarchy from top-level blocks to leaf processes or procedures. The tree may also include packages to group files of different types (see "Packages and folders" on page 8). All diagrams and files referenced by the project tree can be opened from the project manager window by double-clicking on the tree node representing it.

1.2 - Files and directories

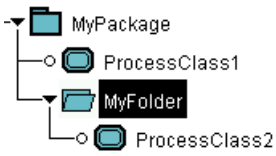
The files associated to nodes in a project tree are stored as relative paths from the directory containing the project file. This mode allows the project to be on a shared disk so that it can be used by several users on different machines. This mode is also suited for sharing a project across different platforms (Windows client and Unix file server, for example).

1.3 - Packages and folders

Within a project tree, files and diagrams may be grouped in two different types of containers:

- *Folders* are just general-purpose containers, not implying any semantics in the files or diagrams it contains;
- *Packages* are also containers for files and diagrams, but also for the elements they contain. A package represents a namespace for all elements described by or within system, block, processe, block class, process class, MSC, HMSC, class and deployment diagrams.

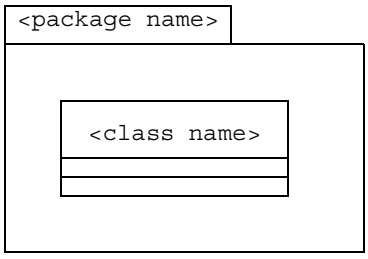
All elements described by or within a diagram which is in a folder are actually in the parent package for this folder. For example:



`ProcessClass1` and `ProcessClass2` are both in the smae package: `MyPackage`. The folder `MyFolder` is just used for grouping and does not imply any organisation on the elements it contains. So any diagram including a "`USE MyPackage;`" in its declarations will be able to instantiate both `ProcessClass1` and `ProcessClass2`.

In a diagram which is in a package, any element is supposed to be in that package, unless stated otherwise. References to elements outside the diagram's package is always explicit: the element is then preceded by the name of its container package followed by '`::`'. There are two other ways of referencing elements outside the current package in a diagram:

- In system, block, process, block class or process class diagrams, a declaration text symbol may be used. Its text must have a line "`USE <package name>;`". All elements in this package are then known in the current diagram, without prefixing by the package name.
- In class diagrams, a class symbol may be enclosed in a package symbol:



Packages and folders may contain other packages or folders. There is no limitation on the number of nested containers within a project.

NB:

- RTDS currently only supports a single "`USE`" in a diagram. All other references must be completely specified using the "`<package>::<name>`" notation.
- Deployment diagrams cannot reference elements in other packages. They must be put in the same package as the system they describe.

1.4 - Supported file types

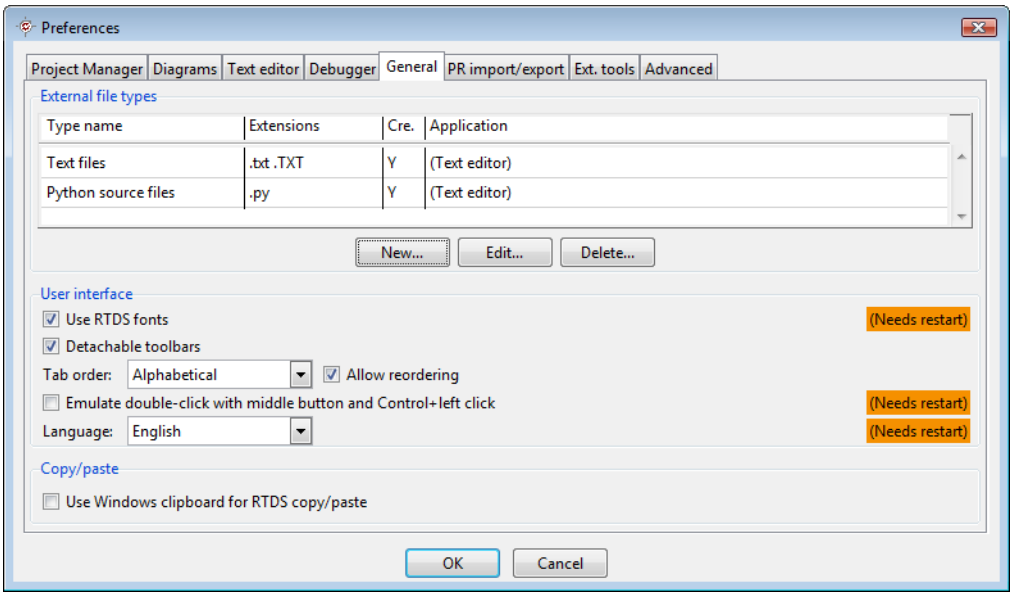
By default, the following file types may be included in a project:

- Diagrams:
  - SDL system,
  - SDL block,
  - SDL block class,
  - SDL process,
  - SDL process class,
  - SDL procedure,
  - SDL composite state (cf. notes 1. & 2. below),
  - SDL service (cf. note 1. below),
  - SDL macro (cf. note 1. below),
  - MSC,
  - High-level MSC,
  - UML use case diagram,
  - UML class diagram,
  - UML deployment diagram,
  - IF observer diagrams.
- SDL/SDL-RT declarations files. The standard extensions for these files is `.rdm`.
- C/C++ files: Source and header files are supported (`.c`/`.cpp` and `.h` respectively).
- TTCN-3 core language files (`.ttcn3`).
- ASN-1 declaration files (`.asn1` or `.asn`).
- Code coverage analysis result files. The standard extensions for these files is `.rdc`.
- RTDS documents. The standard extensions for these files is `.rdo`.
- RTDS prototyping GUIs. The standard extensions for these files is `.rdu`.

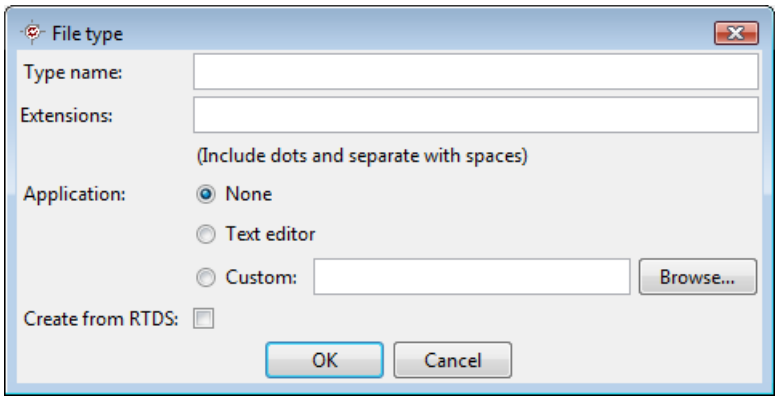
Notes:

1. These diagram types are only available in SDL projects.
2. Composite state diagrams are different from those found in SDL 2000. Please refer to RTDS Reference Manual for a detailed description of the differences.

It is also possible to define new custom file types, allowing to include any file in the project. The definition of custom file types is made in the "General" tab in the preferences dialog, opened via the "Preferences..." item in the "File" menu:



Creating a new custom file type opens the following window:



Notes:

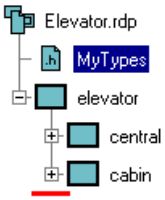
- If the "Application" field is "None", files of this type may be included in the project, but not opened from it
- Setting the application to "Text editor" allows to do text searches and replacements in the file. Otherwise, when doing a text search/replace in the whole project, the file is skipped.
- If "Application" is set to "Custom", a full path to the application executable must be provided in the appropriate field. On Unix, you may only enter the command name if it is in your PATH.
- If the "Create from RTDS" box is checked, it means that files with this type can be created from RTDS project manager. If it is not, existing files with this type may be included in a project, but not created from it. The check-box is on by default when the application is "Text editor" and off in other cases.

- The application used to view the on-line documentation is the one defined for the file type with the extension ".pdf" or ".PDF". A type with one of these extensions must be defined to be able to view the manuals.
- If a custom application is defined for files with the extension `.c`, `.cpp` and/or `.h`, it will be used to open the files instead of the built-in text editor. *Please note* that the second note above still applies: if a custom application is associated with C files, when doing text search and replace in the whole project, these files will be skipped, which is probably not what you want.

1.5 - Rearranging the project tree

The nodes within the project tree may be re-arranged after first creation, including order changing and nesting. These functions can be done either via drag and drop, or using the copy, cut and paste operations. Several nodes can be moved or copied at a time.

When dragging nodes or during pasting, the cursor changes to a horizontal arrow pointing left. Moving this arrow along the project tree will display red horizontal lines at places where the copied node may be pasted:



The red line indicates where the node will be pasted. In the above example, the node will be moved or pasted as a son of the "elevator" node, just after "cabin".

The actual move operation is done by dropping the moved node at the desired position. To cancel a move, release the mouse button where no red line appears.

The actual paste operation is done by clicking on the red line at the desired position. To cancel a paste operation, just press the "Esc" key.

Please note you cannot move or copy/paste block or process diagrams, since what appears in the project manager must be consistent with what appears in the diagrams.

1.6 - Adding components to the system

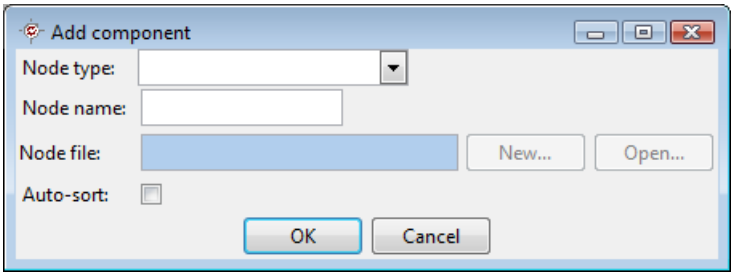
There are three ways of adding components to your project:

- You can directly add components one by one via the project manager in the project tree. This operation is described in “Adding a single component” on page 12.
- You can import a whole directory with all its sub-directories in the project tree. This operation is described in “Importing a directory” on page 12.
- Operations on diagrams may also automatically add a node in the project tree. This operation is described in paragraph “Creating and opening components” on page 59. This way is used to create the part of the project tree that is mapped to the block/process hierarchy

1.6.1 Adding a single component

This is the preferred way when dealing with packages, source files or top-level nodes for diagrams (such as systems, block or process classes, UML diagrams, MSC diagrams, etc...).

To add a component to a node via the project manager, just select the parent node for the new node, drop down its contextual menu with the right mouse button and select the "Add component..." item (or menu "Element", item "Add component..."). The following dialog appears:



The fields in this dialog are the following:

- Node type: the type for the node / file to create. The available types are the ones listed in “Supported file types” on page 9, plus the type "Package". The only active items are the valid types for children of the selected node.
- Node name: the name appearing for the node in the project tree. If not set, this field will be automatically set if you choose a file in the "Node file" field.
- Node file: the name of the file associated to the node. This field cannot be set if the node’s type is "Package", since packages have no associated file. Otherwise, the field can only be modified via the "New" and/or "Open" buttons.
- Auto-sort: allows to ensure a consistent order in the parent’s child nodes. If this option is checked, folders are placed first in alphabetical order, then packages, then all other children. Note this option will only work if the parent’s existing children are already sorted. Otherwise, the behavior is undefined.

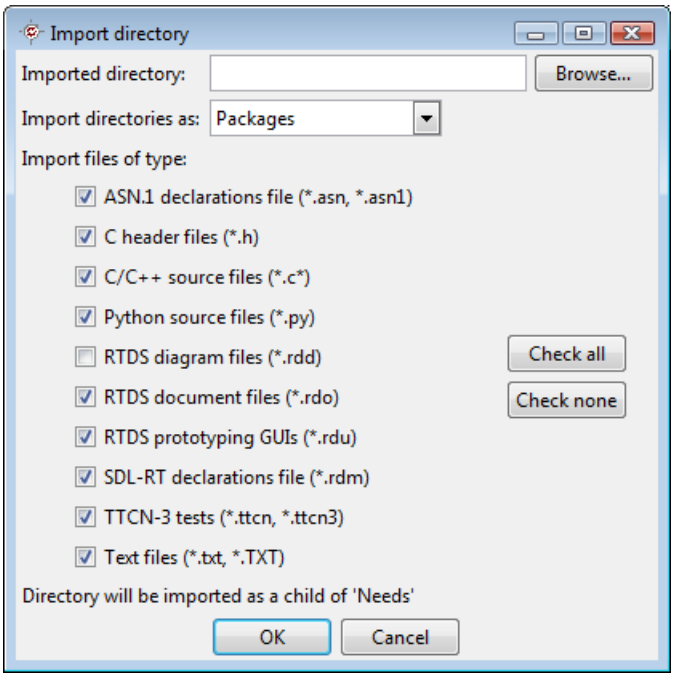
To add the child node, fill in all active fields and validate the dialog. The new node then appears in the project tree.

For the "Node file" field, selecting the file via the "New..." button allows to create a new empty component and selecting it via the "Open..." button allows to attach the component to an already existing file. Please note that if you select the file using "New..." and if you choose an already existing file, the file will be erased before the component is created.

1.6.2 Importing a directory

When a project is created, some files that should be included in it may already exist. For example, if a project uses an existing code library, but that may evolve with the project, all the files in this library should be included in the project for convenience. This can be achieved easily in RTDS by using the directory import function. First select the package that will be the parent of the imported file, then select the "Import directory..." item in

the "Element" menu of the project manager. The import directory options dialog appears:



This window allows to select the directory to import and the type of the files that will actually be imported in the project tree. The file types that appear are standard RTDS types (C source and header files, diagram files) and all the external file types (see “Supported file types” on page 9). The actual import will create one node for each file with one of the selected types, mapping directories to packages.

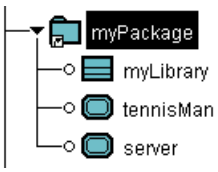
Important note: checking the "RTDS diagram files" type in the previous dialog will probably not have the result you expect, because the diagram node hierarchy will *not* be re-created by this function. The directory import function treats the diagram files exactly like other files, which means it just creates the corresponding node without analyzing the contents of the file. Since the diagram hierarchy is described in the diagrams themselves, it cannot be re-created. If the checkbox for diagrams is checked in the directory import options dialog, a message will warn you about this issue.

1.7 - Sharing project parts

It is possible to export a part of a project and to dynamically import it in another project. All changes made to the shared part in any project will be automatically seen in all other projects.

Any sub-tree in a project can be shared. To export a sub-tree, select its root node and select "Export element sub-tree" in the "Element" menu. The sub-tree is exported to a file

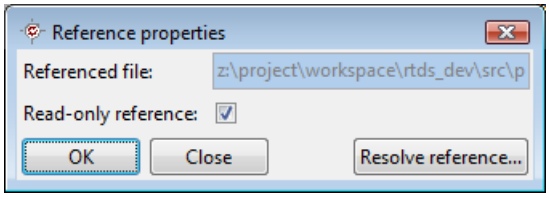
with a `rdx` extension. Once exported, the icon for the sub-tree root will be displayed in the project manager as follows:



The small arrow in the icon's lower left part indicates that the sub-tree is shared.

To import the sub-tree in another project, select the node under which the sub-tree should be inserted and select "Import element sub-tree" in the "Element" menu, then select the `rdx` file for the sub-tree to import. The whole sub-tree appears under the selected node. The icon for the imported sub-tree will be displayed with the same small arrow as the the project from which it was exported.

It is also possible to make a read-only reference. In this case, RTDS forbids the modification of any element in the imported sub-tree. To make a reference read-only, open its properties via the menu 'Element', then 'Reference properties...', and check the 'Read-only reference' checkbox:



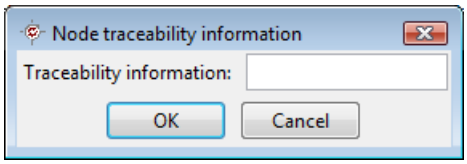
NB:

- There is no difference in the representation for shared sub-trees in the project from which it was exported and in the project into which it was imported. This is intentional, since after the sub-tree has been exported and imported, there is no difference between both projects: a change on any of them will be seen in both.
- Make sur the `rdx` file is not deleted or moved, or the sub-tree will disappear from both projects.
- To cancel the sharing of a sub-tree in a project, select its root node and display its reference properties via the corresponding item in the "Element" menu. In the dialog, click on the "Resolve reference" button. The sharing will then be cancelled and the icon will no more be displayed with the small arrow.

1.8 - Interface with traceability tools

Traceability information can be added to RTDS projects, enabling to connect it to requirement management tools such as Reqtify. This information is added in the project itself to individual nodes in the tree: diagrams, files, packages, ...

The traceability information for a node can be viewed or changed by selecting the node and choosing the item "Traceability information..." in the "Element" menu. The following dialog is then displayed:



If some information has already been entered for the node, it will be displayed in the "Traceability information" field. Changing this field, validating the dialog and saving the project will change the information for the node.

Note RTDS doesn't interpret the traceability information at all. It is just saved in the project XML file as an attribute for the node. The interpretation of the information is done by the requirement management tool.

For more details and the description of the integration with the Reqtify tool delivered with RTDS, see the corresponding section "Traceability information" on page 36.

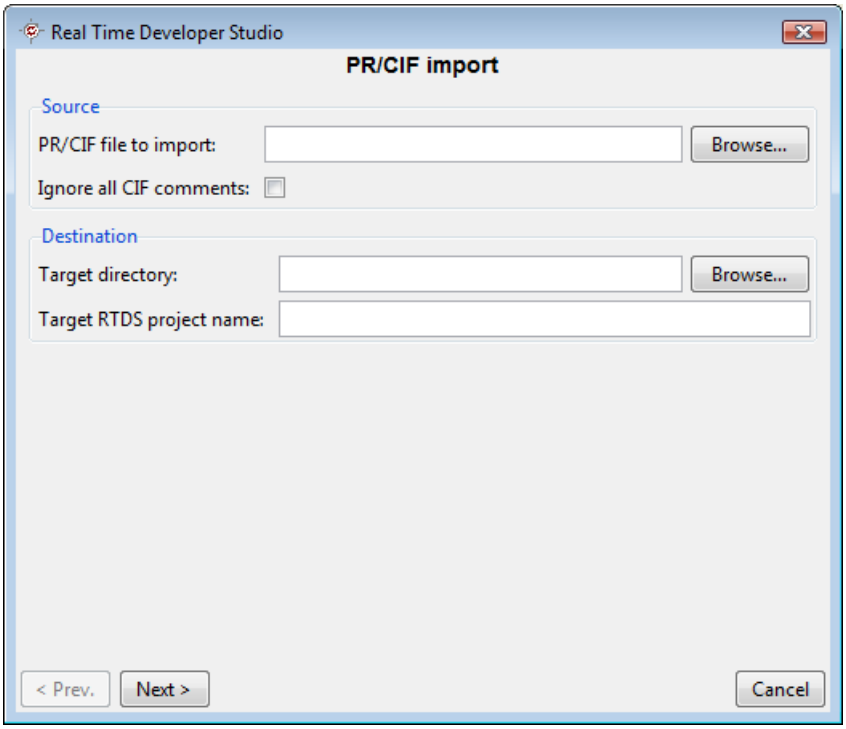
1.9 - Importing a PR/CIF file

PR (Phrasal Representation) and CIF (Common Interchange Format) files are ITU-T standards to exchange SDL models from one tool to another. RTDS allows to import a file in SDL PR/CIF format to a RTDS SDL project file. This is done via the "*Import PR/*

CIF file..." item in the "*Project*" menu. The import configuration is made via a wizard; The panels in this wizard are described in the following paragraphs.

1.9.1 Source & destination panel

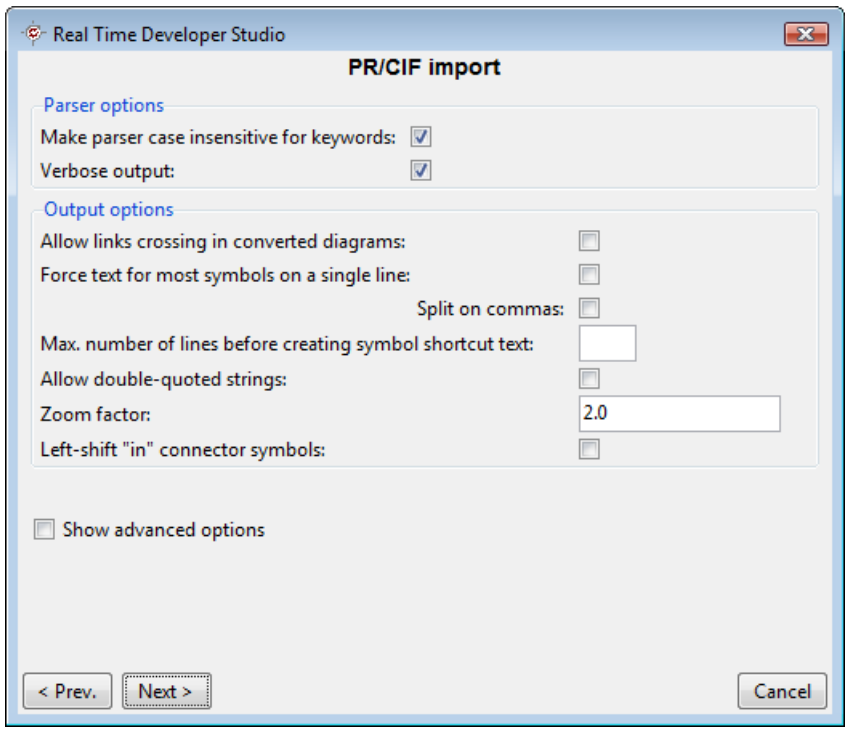
The first panel in the PR/CIF import wizard is the following:



The "*PR/CIF file to import*", "*Target directory*" and "*Target RTDS project name*" should be set to the name of the file to import, the destination directory for all created files and the name to given to the RTDS project file respectively. If the "*Ignore all CIF comments*" option is not checked, RTDS will expect to find valid CIF comments in the imported file and will use them to set the positions and sizes for all symbols. If the comments are not present or wrong, the import may fail. If the comments are not present, or wrong, or if they should be ignored for any reason, the option must be checked. RTDS will then automatically place and size the symbols.

1.9.2 Basic options panel

The next panel are the basic import options:



The options in this panel are:

- *Make parser case insensitive for keywords*: by default, only keywords all in uppercase or all in lowercase are considered. Checking this option allows to import a file with keywords in any case.
- *Verbose output*: By default, only error or warnings messages are displayed. This option allows to also display messages about the conversion progress.
- *Allow link crossing in converted diagrams*: This option allows links to cross other links in all converted diagrams, including systems and blocks.
- *Force text for most symbols on a single line*: By default, the text for symbols is taken as it is in the imported file. This option allows to put these texts on a single line, except for "naturally" multi-line symbols such as declarations or task blocks.
- *Split on commas*: Used with the previous one, this option will insert a newline after each comma in the symbol text.
- *Max. number of lines before creating symbol shortcut text*: Automatically creates a shortcut text for a symbol when the number of text lines is above the given threshold. If this option is blank, no shortcut text will ever be created.
- *Allow double-quoted strings*: Some SDL tools allow strings to start and end with double-quotes instead of single quotes as specified in the standard. Check this option if the tool used to create the files to import allowed this.
- *Zoom factor*: Only available when considering CIF comments. All positions and sizes in these comments will be multiplied by this factor.
- *Left-shift "in" connector symbols*: Only available when considering CIF comments. This option controls how "in" connector symbols (labels) are placed in the bounding box specified in the CIF comments for the symbol:

- With the option unchecked, the symbol will be placed as follows:

- With the option checked, the symbol will be placed as follows:

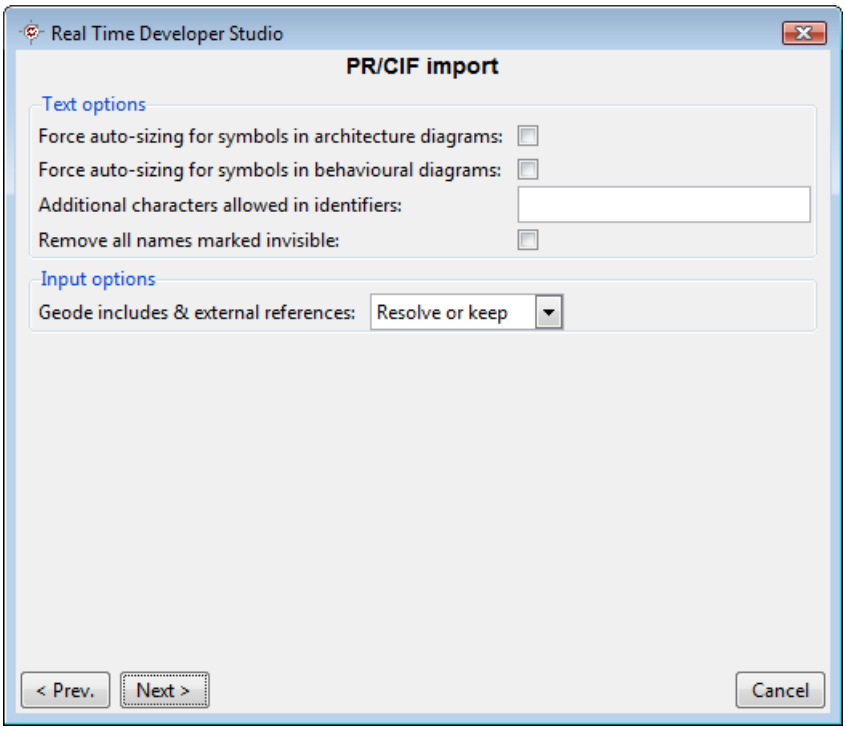
This option should be checked when importing files from Geode / ObjectGeode.

- *Create one partition for each state*: Only available when CIF comments are ignored. This option will automatically create a new partition for each `STATE` encountered in the imported PR file.

The next two panels are only displayed if the "*Show advanced options*" checkbox is checked in the basic options panel. Otherwise, the wizard goes directly to the summary panel (cf. “Summary panel” on page 20).

1.9.3 Advanced options panels

The first advanced options panel is the following:

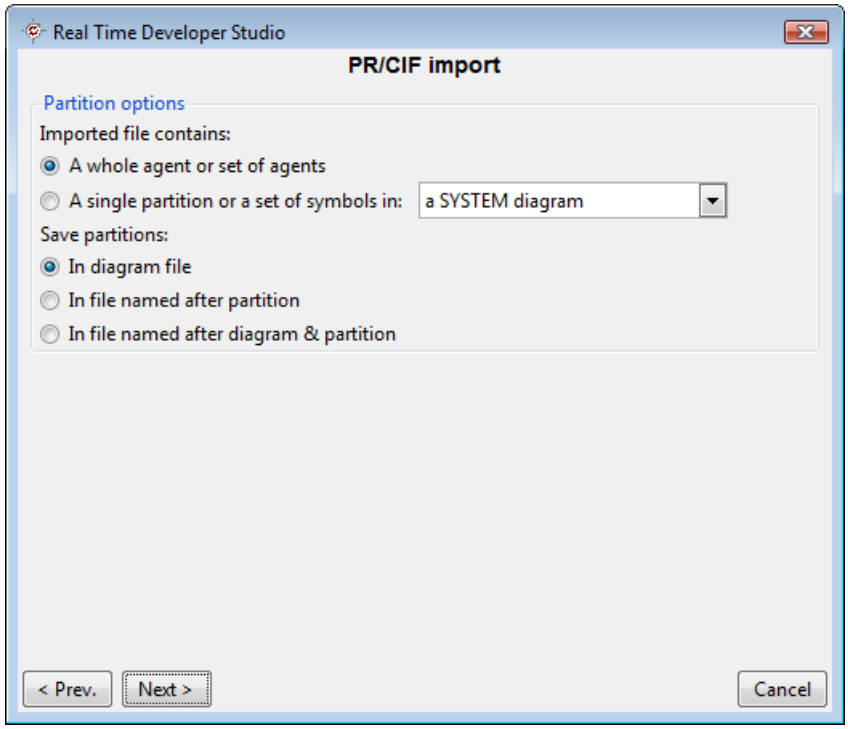


The options are:

- *Force auto-sizing for symbols in architecture diagrams*: Will automatically adapt the symbol dimensions to their text for all symbols in architecture diagrams.

- *Force auto-sizing for symbols in behavioural diagrams*: Same as the previous option, but for behavioural diagrams (processes, procedures, services and macros).
- *Additional characters allowed in identifiers*: By default, RTDS only allows letters, digits, underscores and dots in identifiers. This field can be used to add characters that will be considered as valid in identifiers. Please note that specifying characters meaningful in the SDL syntax may have unpredictable results. Using special characters such as `@` or `%` should however not cause any problem.
- *Remove all names marked invisible*: Only available when CIF comments are considered. With this option checked, all names marked as invisible in the CIF comments in the imported file will not be used in the created diagrams.
- *Geode includes & external references*: Specify how Geode "CIF includes" and "`COMMENT '#ref …'`" will be handled in the imported project:
  - If this option is set to "*Resolve or keep*", the included or referenced file will be imported if it exists, or the reference on it will be kept, either as text or as a symbol PR code suffix (cf. “Symbol and link properties” on page 50).
  - If this option is set to "*Resolve or discard*", the included or referenced file will be imported if it exists, or the reference will be discarded. So the name of the referenced file will not appear anywhere in the converted diagrams.
  - If this option is set to "*Always keep*", the included or referenced files will never be imported and the reference will be kept as text or a symbol PR code suffix.

The second advanced options panel is:


Real Time Developer Studio
PR/CIF import
Partition options
Imported file contains:
A whole agent or set of agents
A single partition or a set of symbols in:
a SYSTEM diagram
Save partitions:
In diagram file
In file named after partition
In file named after diagram & partition
< Prev.
Next >
Cancel

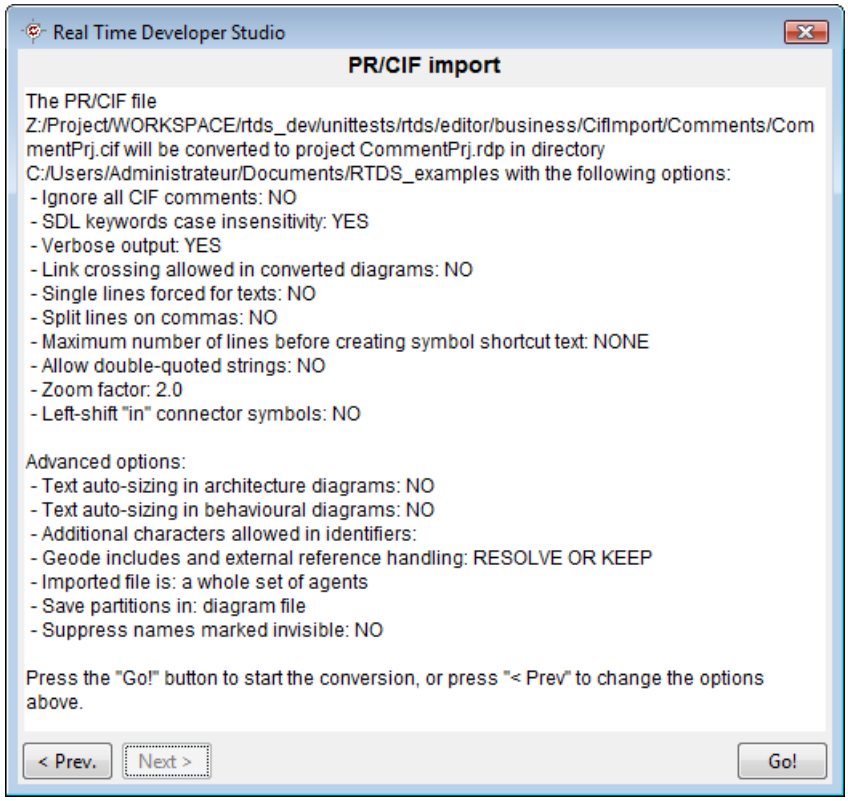
The option "*Imported file contains*" allows to import PR/CIF files containing only a part of a diagram. If this option is set to a diagram type, the imported file will be considered as containing only a part of a diagram of this type. The imported project will then include a

diagram with this type marked as a diagram extract. If this diagram is exported back to a PR file, no heading or end marker will be created in the file.

The "*Save partitions*" options allows to control if partitions created in the converted diagrams will be saved in the diagram file or in an external file. If they are saved in an external file, the computed name for the partition file may include either the partition name alone or the diagram name and the partition name.

1.9.4 Summary panel

The last panel in the PR/CIF import wizard is the summary panel:


Real Time Developer Studio
PR/CIF import
The PR/CIF file Z:/Project/WORKSPACE/rtds_dev/unittests/rtds/editor/business/CifImport/Comments/CommentPrj.cif will be converted to project CommentPrj.rdp in directory C:/Users/Administrateur/Documents/RTDS_examples with the following options:
- Ignore all CIF comments: NO
- SDL keywords case insensitivity: YES
- Verbose output: YES
- Link crossing allowed in converted diagrams: NO
- Single lines forced for texts: NO
- Split lines on commas: NO
- Maximum number of lines before creating symbol shortcut text: NONE
- Allow double-quoted strings: NO
- Zoom factor: 2.0
- Left-shift "in" connector symbols: NO
Advanced options:
- Text auto-sizing in architecture diagrams: NO
- Text auto-sizing in behavioural diagrams: NO
- Additional characters allowed in identifiers:
- Geode includes and external reference handling: RESOLVE OR KEEP
- Imported file is: a whole set of agents
- Save partitions in: diagram file
- Suppress names marked invisible: NO
Press the "Go!" button to start the conversion, or press "< Prev" to change the options above.
< Prev.
Next >
Go!

This is a summary of all options chosen in the previous panels. Pressing the "Go!" button in the panel will actually start the import.

1.9.5 PR/CIF import progress and result

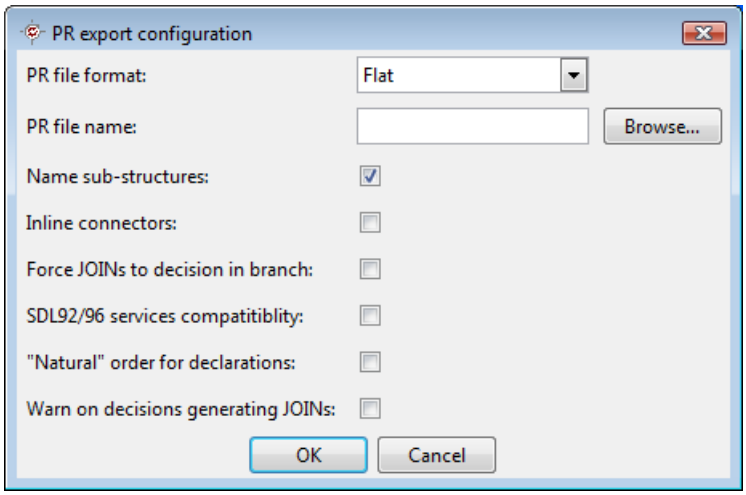
Once the import has started, a dialog will appear displaying all messages returned by the conversion, including warning and error messages if any and progress messages if the "*Verbose*" option was checked. All warnings and errors will also be saved in the converted project and displayed each time the project is loaded. Double-clicking on a message will automatically open the concerned diagram, allowing to check the conversion result or to correct the problem if any.

1.10 - Importing a MSC-PR file

RTDS allows to convert a MSC PR file as defined in the ITU-T Z120 standard to a RTDS MSC diagram file and to include it in an existing project. This feature is described in detail in paragraph “MSC PR import” on page 81. Note that the conversion does not produce a project file, but only a diagram file. So a project must be opened in the project manager to be able to import MSC-PR files.

1.11 - Exporting the project as a SDL/PR file

The item "*Export as PR...*" in the "*Project*" menu displays the following dialog:



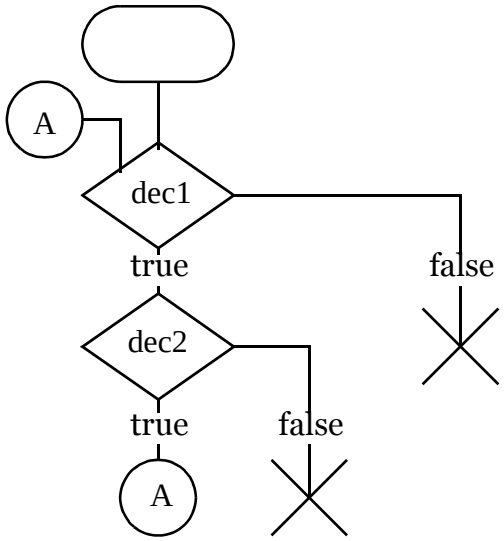
The PR file format indicates how agent definitions will be inserted in the exported file:

- In a "*Flat*" PR file, an agent defined in another one will be defined as `REFERENCED` in its parent and its definition will appear later in the file. The definition will be fully qualified to avoid ambiguities.
- In a "*Hierarchical*" PR file, an agent in another one will have its whole definition included in its parent’s. No qualifier will be inserted as no ambiguity can occur.

The options are:

- *Name sub-structures*: By default, the `SUBSTRUCTURE` declarations created for blocks containing other blocks are not named. If this option is checked, a `SUBSTRUCTURE` name will also be inserted, which will be the same as the parent block’s name.
- *Inline connectors*: By default, all connectors are put in `CONNECTION` blocks outside the transitions. If this option is checked, no `CONNECTION` blocks will be created and a label will be inserted for each connector in the middle of the first transition that uses it.

- *Force JOINs to a decision branch*: By default, a JOIN to a label in front of a decision can be put anywhere. This means for example that the following diagram:



may be exported as:

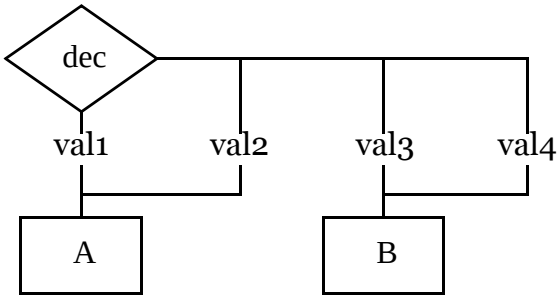
```
START;
  A:
  DECISION dec1;
    (true):
      DECISION dec2;
        (true):
          JOIN A;
        (false):
          STOP;
      ENDDECISION;
    (false):
      STOP;
  ENDDECISION;
```

This is sometimes not desirable, since the JOIN to the label before the first DECISION is generated in a branch of the second DECISION. This makes it difficult for external code generators to figure out that the JOIN may actually be converted to a while-style loop.
Checking the "*Force JOINs to a decision branch*" option will always try to put JOIN statements to a DECISION in one of this DECISION's branches. So the diagram above would be exported as:

```
START;
  A:
  DECISION dec1;
    (true):
      DECISION dec2;
        (true):
        (false):
          STOP;
      ENDDECISION;
      JOIN A;
    (false):
      STOP;
  ENDDECISION;
```

- *SDL 92/96 services compatibility*: By default, processes defining composite states are exported as such in the PR file, using the SDL 2000 syntax for composite states. Checking this option will try to export them as SDL 92/96 processes containing services. To be able do this, the processes must:
  - Define at most one composite state;
  - If they do, have only a start transition containing a single `NEXTSTATE` symbol to this composite state.

  In this case, the services defined at composite state level will be put directly into the parent process using a SDL 92/96 syntax for services. If any process does not meet these constraints, the export will fail.
- *"Natural" order for declaration*: By default, all declarations and decision branches are exported with no specific order. The order may even change from one export to another, even if the diagrams have not changed. Checking this option will force a deterministic order on exporting. This order is the "natural" one when available, i.e the order of the symbols in the diagrams.
- *Warn on decisions generating JOINs*: There are some cases where a decision in a diagram cannot be exported without generating an additionnal label. Here is such a decision:



One of the task blocks `A` or `B` can be put after the `ENDDECISION`, but for the other one, a label must be generated or the symbol's code will have to be duplicated in the exported PR.
By default, this additionnal label is silently generated. This option forces a warning to be displayed if such a label is generated.

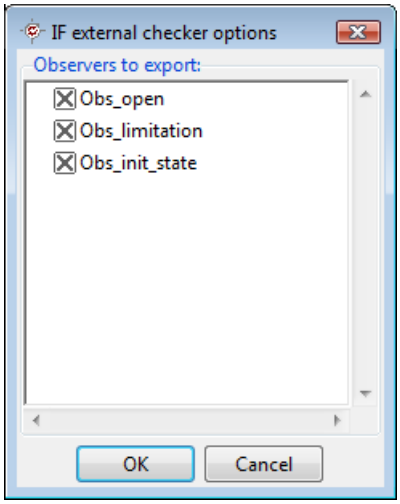
Note: The PR export is available in all project types, but is likely to produce an interesting result only for Z100 SDL projects. A warning will be displayed if it is attempted on another type of project.

1.12 - Exporting a project as a Verimag IF file

RTDS allows to export a whole project in the IF language as defined by Verimag. For the current possibilities and limitations, refer to the corresponding chapter in the Reference Manual.

It is also possible to define an external model checker based on IF in the preferences. It will then be directly called from the project manager and can produce MSC diagrams for error cases. The way to configure the external checker is described in to “External tools preferences” on page 31.

For both features, if IF observer diagrams exist in the current project, RTDS will ask which ones should be exported with the system via the following dialog:



1.13 - Exporting elements as HTML files

There are two ways of exporting elements as HTML files:

- Exporting a single element
- Exporting the whole project

These two ways are described in the paragraphs below.

1.13.1 Exporting a single element

Exporting an element is done via the "Save element as HTML..." item in the "Element" menu. An element must be selected in the project tree.

When exporting, all elements referenced by the exported one are also recursively exported, and links are created for each referenced element. For example, if the exported element is a block diagram and includes a process symbol, the element describing this process is also exported. In the HTML file for the block, a link will be created on the process symbol which will open the HTML file for the process.

The destination directory for all the HTML files is asked to the user.

1.13.2 Exporting the whole project

Exporting the whole project is done via the "Export as HTML..." item in the "File" menu. This kind of export does the same thing than exporting all elements in the project, but also generates an HTML file for the whole project. This file includes two frames: the one at left hand contains a representation of the project tree and the one at right hand may contain any HTML file for any element in the project. Clicking on a node in the left frame opens the corresponding element in the right one.

The file name for the HTML file for the project is asked to the user. All other HTML files will be generated in the same directory than this file. If a file in this directory has the name of a generated file, it will be silently replaced.

1.14 - Export all the publications in a whole project

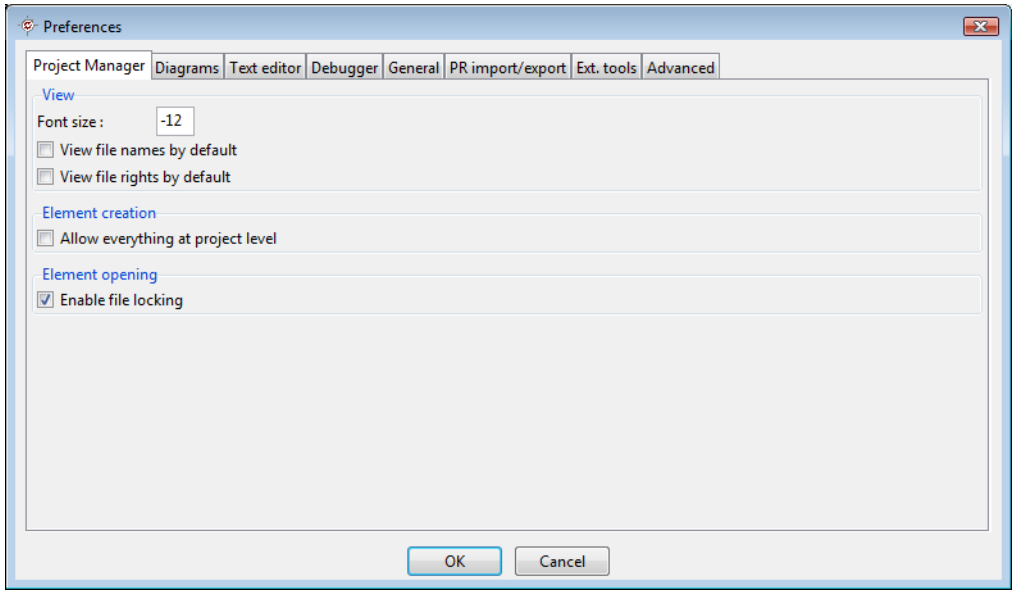
RTDS allows to export diagrams or parts of diagrams as publications to be able to include them in external documentation. Publications are described in “Publications” on page 54.

It is possible to export all publications in all diagrams in a whole project. This allows to be sure that everything is up to date in the external documentation. Please note that this function will open all diagrams in the project, even if they have no publications at all. So it may be quite long for large projects.

1.15 - Preferences

The preferences for the application are opened via the item "Preferences..." in the "File" menu. The dialog that appears is divided in tabs, that are described in the following paragraphs.

1.15.1 Project manager preferences

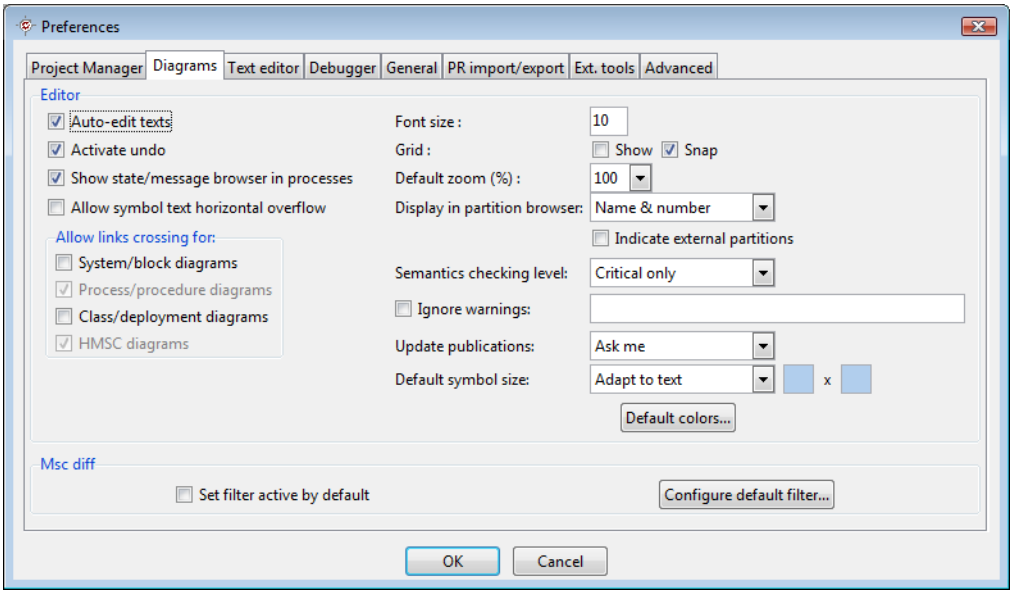


The "*View file names by default*" and "*View file rights by default*" options control whether the file names and/or access rights will be automatically displayed in the project manager window when a project is opened.

The option "*Allow everything at project level*" allows to create any kind of diagram directly in the project. By default, no other SDL diagram than systems can be created at project level.

The option "*Enable file locking*" controls whether the files you open for modification are locked for your personal use or not. If this option is set, two users cannot modify the same file at the same time.

1.15.2 Diagram preferences



The "*Auto-edit text*" option controls whether the text for symbols or links will be automatically opened for modification when the symbol or link is created.

The "*Activate Undo*" option activates the undo operation in the diagram editor. Deactivating the undo can speed up editing on very large diagrams.

The "*Show state/message browser in processes*" controls whether the browser allowing direct access to transitions for each state and input message is displayed when opening a process. Refer to paragraph “"View" / "Go to" menu and state / message browser” on page 64 for further details on this browser.

The "*Allow symbol text horizontal overflow*" controls how the text is displayed if it is too large for the symbol. With this option unchecked, the text will be as wide as the symbol and will overflow only above and below the symbol. With this option text, no width will be defined for the text and it may overflow on all sides of the symbol, including left and right sides.

The options in the "*Allow links crossing*" group set on which diagram the crossing of links will be allowed. This option is today always set for process, procedure and HMSC diagrams. It can be activated for system, block, class and deployment diagrams by checking the corresponding check-box. Please note once a diagram is saved when the corresponding option is on, the crossing of links will be definitely allowed for the diagram. There is no way to forbid link crossing for a diagram that allows them.

The font size is the font size for diagrams. It does not apply in the source file editor.

The "*Grid*" options control the default behavior of the grid in diagram editors: If the "*Show*" check-box is checked, the grid will appear; if the "*Snap*" check-box is checked, all objects will align automatically to the grid.

The "*Default zoom*" is the initial value for the zoom level for all diagram windows.

The "*Display in partition browser*" option controls what is displayed in the partition browser in diagram editors. The display may include the partition order number, its

name or both. If the "*Indicate external partitions*" checkbox is checked, partitions stored in external files will be prefixed with a '*' in the browser.

The "*Semantics checking level*" option can be set to:

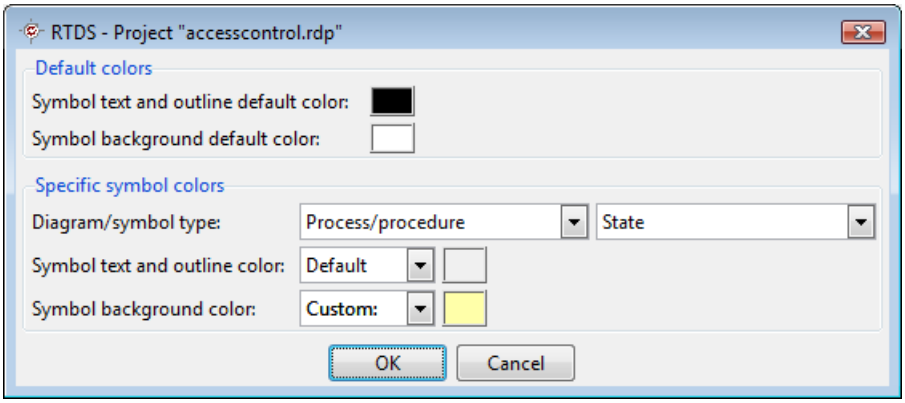
- "All" to report errors for any problem
- "Critical only" to report errors only for problems preventing the system to work and only warnings for other problems

The "*Ignore warnings*" checkbox and entry allow to specify which warnings won't be displayed during a syntax / semantics check. If the box is not checked, all warnings are displayed. If the box is checked, warnings having the identifiers specified in the entry will not be displayed. The warning identifiers should be separated with spaces. Warning identifiers are documented in RTDS Reference Manual.

The "*Update publications*" option controls whether the publications of a diagram will be automatically saved when the diagram is saved. See paragraph "Publications" on page 54.

The "*Default symbol size*" option controls how symbol are sized when created. If this option is set to "*Adapt to text*", the symbol size will not be fixed and will adapt to whatever text is entered in it. The other option is "*Set to:*" and requires a default size to be entered. If these are set, all symbols will have the specified size when created. The unit for the size are printer points (same unit as font sizes).

The "*Default colors*" button allows to set the default colors for all symbols in diagrams depending on their type. Pressing this button opens the following dialog:



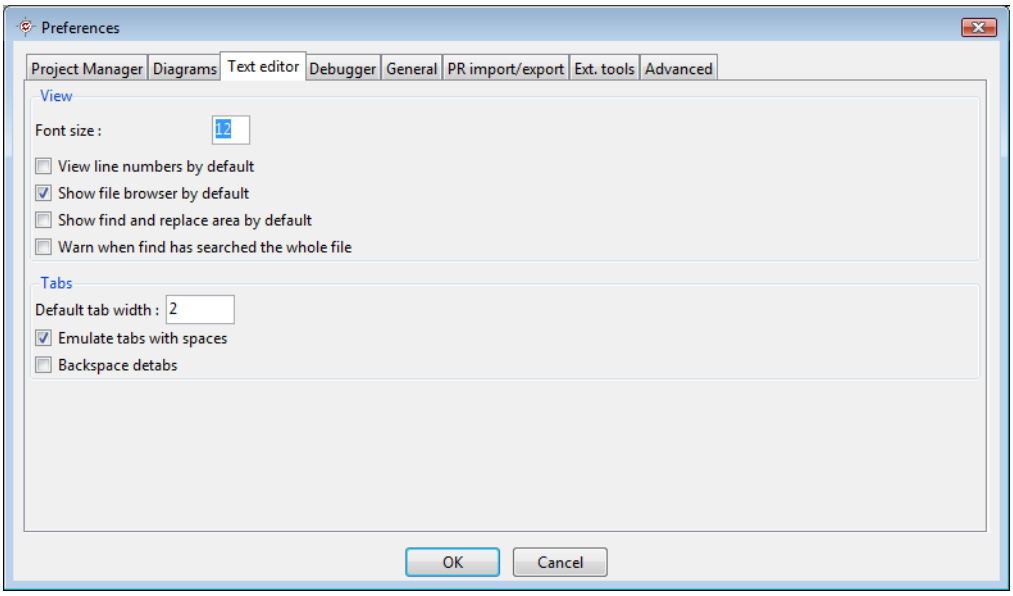
To change the default color for all symbols, select the colors in the upper part of the dialog. Two colors may be selected: the one for outline and text and the one for background.

To assign specific colors to all symbols with a given type, select its parent diagram type and symbol type in the corresponding menus. Its current outline and background colors are then displayed in the lower part of the dialog. Specifying new colors will override the default ones for all symbols with the selected type.

Please note the default colors only applies when the symbol is created. All symbols keep the colors set when they were created, so setting colors in this dialog will not change symbols in existing diagrams. Colors for specific symbols may be changed via the symbol properties dialog in the diagram editor (see "Symbol and link properties" on page 50).

The options in the "*MSC diff*" group are the default values for the filter when doing a MSC diff / merge. A detailed description of these options can be found in paragraph “MSC Diff” on page 74.

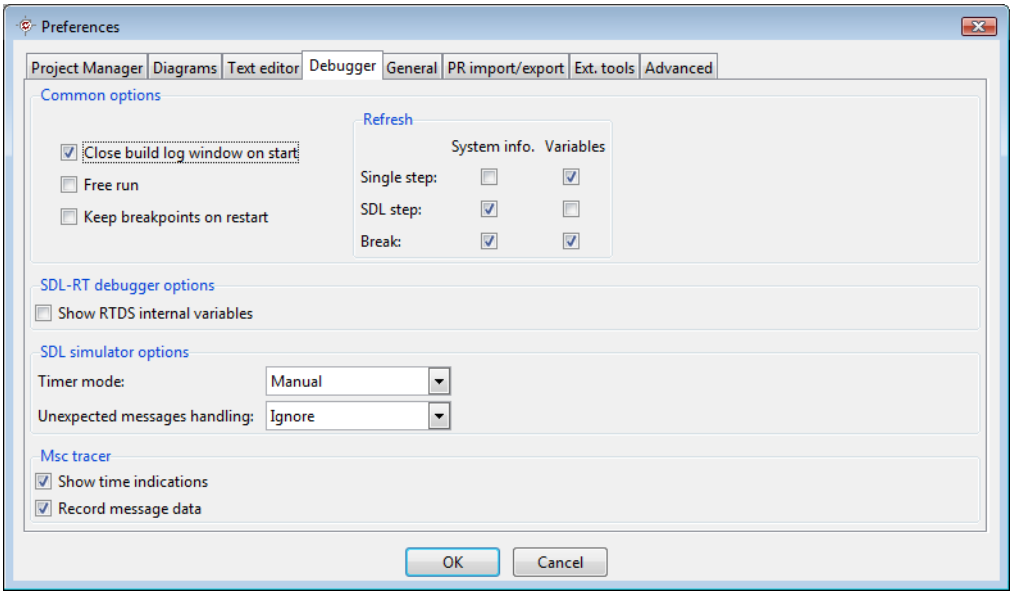
1.15.3 Text editor preferences



These options are the default values for those found in the "Preferences" menu in the text editor. They control:

- The font size for texts ("*Font size*");
- The visibility of the line numbers ("*View line numbers by default*");
- The visibility of the class/method/function browser ("*Show file browser by default*");
- The visibility of the find / replace bar in the editor ("*Show find and replace area by default*");
- Whether the search function should warn when the whole current file has been searched (“*Warn when find has searched the whole file*”);
- The width for tab characters ("*Default tab width*");
- Whether the "Tab" key should insert hardware tabs or spaces ("*Emulate tabs with spaces*");
- Whether the backspace key should act as if it deleted a tab ("*Backspace detabs*"). This behavior is only active when there is only whitespace between the beginning of the line and the current position.

1.15.4 Debugger preferences



The options in "Options" are the default values for those found in the "Options" menu in the SDL-RT debugger and SDL simulator windows. They're described in chapters "SDL-RT debugger" on page 187 and "SDL Z.100 Simulation" on page 222.

In the "Msc tracer" options, "*Show time indications*" controls whether timing information for the executed system are included in the trace as absolute time constraints symbols or not. "*Message data*" controls how the data associated to the exchanged messages will be displayed (completely, only `n` bytes or not at all).

1.15.5 General preferences

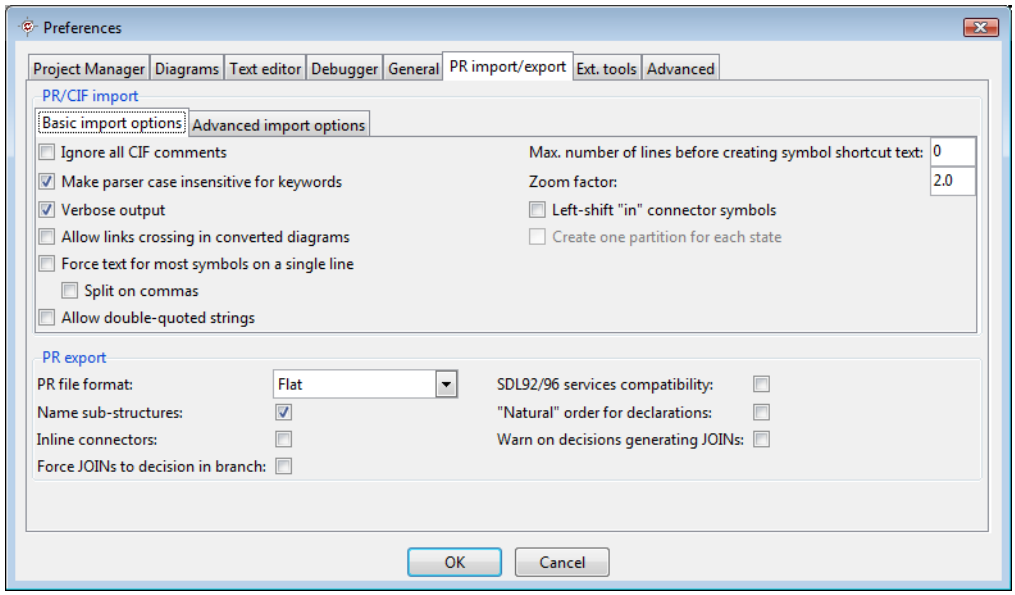
This tab is shown in paragraph "Supported file types" on page 9. It contains:

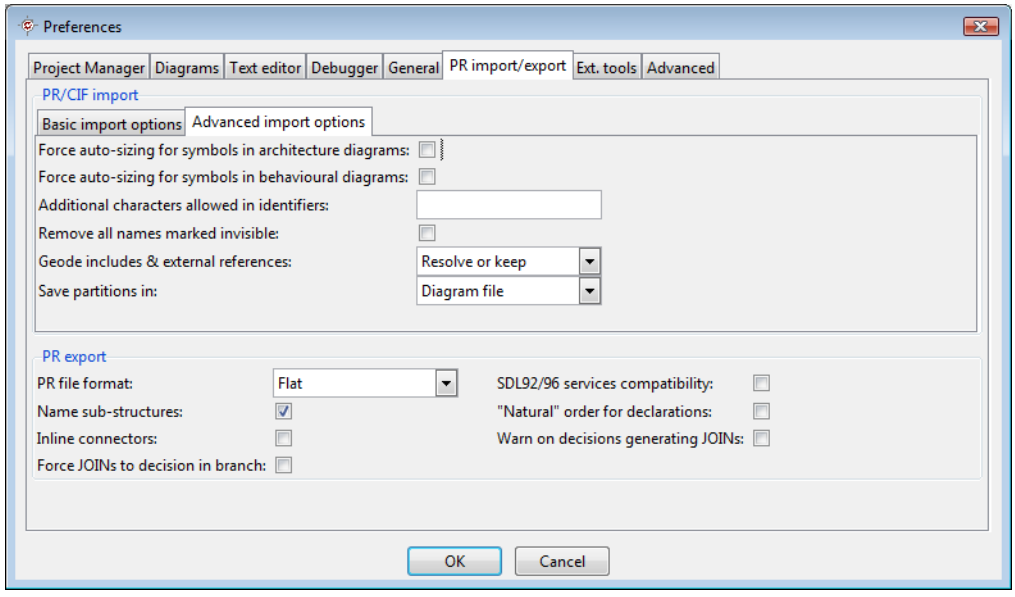
- The external file types defined for the application
- The option setting the font for diagrams and source files to the font delivered with RTDS. This option will be automatically set when RTDS is launched for the first time.
- The options "*Detachable toolbars*" makes the toolbars in the various editors detachable from their parent window.
- The option "*Tab order*" determines how atbs will be ordered in the editor windows. Values are "*Latest last*", "*Latest first*" or "*Alphabetical*". If the "*Allow reordering*" option is checked, it will possible to reorder tabs in their parent window. Note that detaching tabs is always possible.
- The option allowing to emulate a double-click with a middle click or a control-left click. This can be used as a workaround for a bug in some versions of Windows where the double-click does not work with RTDS.
- The language setting for RTDS user interface; when this setting is modified, RTDS will have to be restarted for the changes to appear.
- On Windows, whether the copy / paste operation for diagrams should use the regular Windows clipboard or RTDS own internal one. In the first case, copying symbols from one RTDS instance to another will be possible, but it will delete the

former clipboard contents and have unexpected results if symbols are pasted in anything else than RTDS. In the second case, it will be impossible to paste copied symbols in anything else than the current RTDS instance, including other RTDS instances.
NB: This option is not available on Unix as copied symbols can only be pasted in another RTDS.

- On Unix, the default print command to use for all print operations.

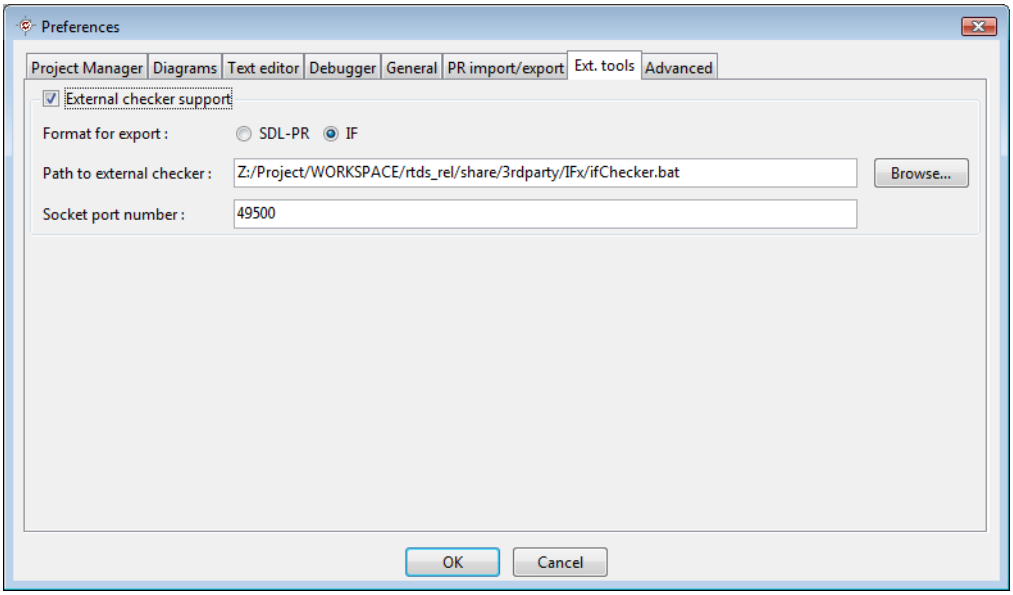
1.15.6 PR import & export preferences





These preferences are the default values for most of the PR import & export options. The description of these options can be found at paragraphs “Importing a PR/CIF file” on page 15 and “Exporting the project as a SDL/PR file” on page 21 respectively.

1.15.7 External tools preferences



These preferences are used to activate the communication between RTDS and external tools. The only available external tool today is an external model checker. This checker can be based either on the PR format or on the IF format as defined by Verimag. It also can send back the results of the check as MSC traces via a socket. The options in the dialog are the format for the export, the full path to the external checker and the socket port number on which RTDS should expect the MSC traces to be sent.

Checking the "*External checker support*" check box will cause a new menu to appear in the project manager, labelled "Tools", and containing only an item for the external model checker.

More details on the external model checker and the principles for the SDL to IF conversion can be found in the Reference Manual.

1.15.8 Advanced options

As their name implies, these options are for advanced users only. They should be left to their default values except on explicit advice from the PragmaDev support team.

1.16 - User defined external tools

The project manager allows to define a set of external tools that may be used on the files in the project or on the project itself. A typical use of these tools is to interface Real Time Developer Studio with a configuration management system, but their use is much larger than that.

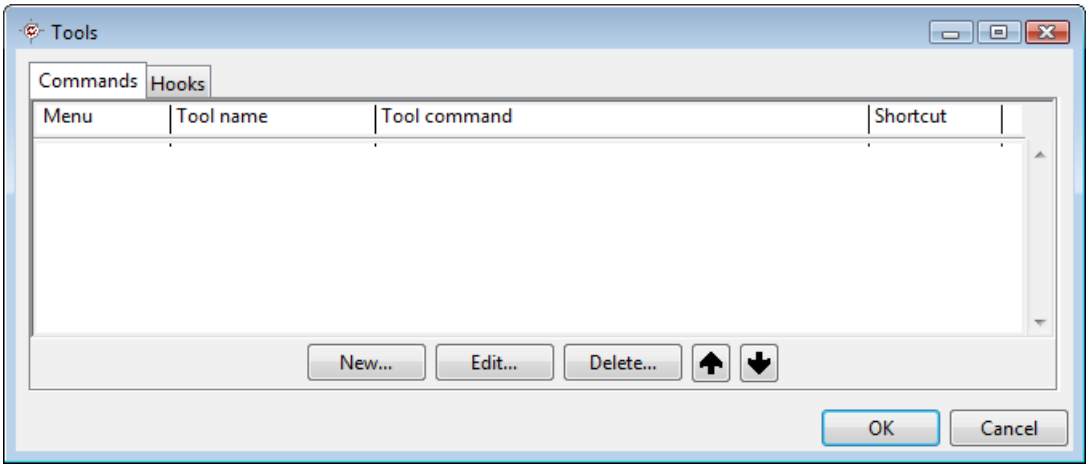
External tools appear in new dynamic menus in the project manager. They are defined via the "Tools..." sub-menu in the "File" menu of the project manager. The three items in this sub-menu are:

- "Configure...", allowing to manage external tools (see below),

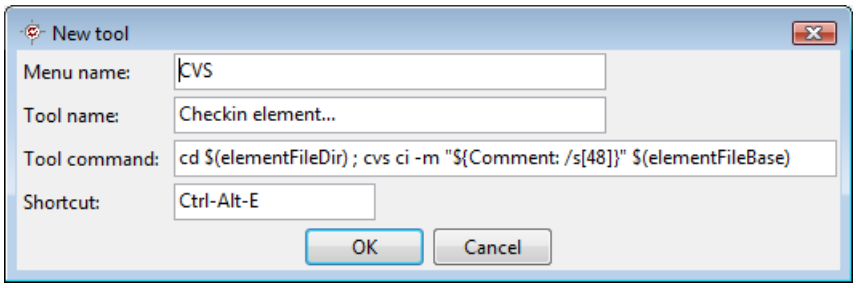
- "Import..." and "Export...", allowing to share tool definitions between different users using a representation of these definitions in a text file.

1.16.1 Tool menus definition

The "Tools / Configure..." sub-menu opens the following window:

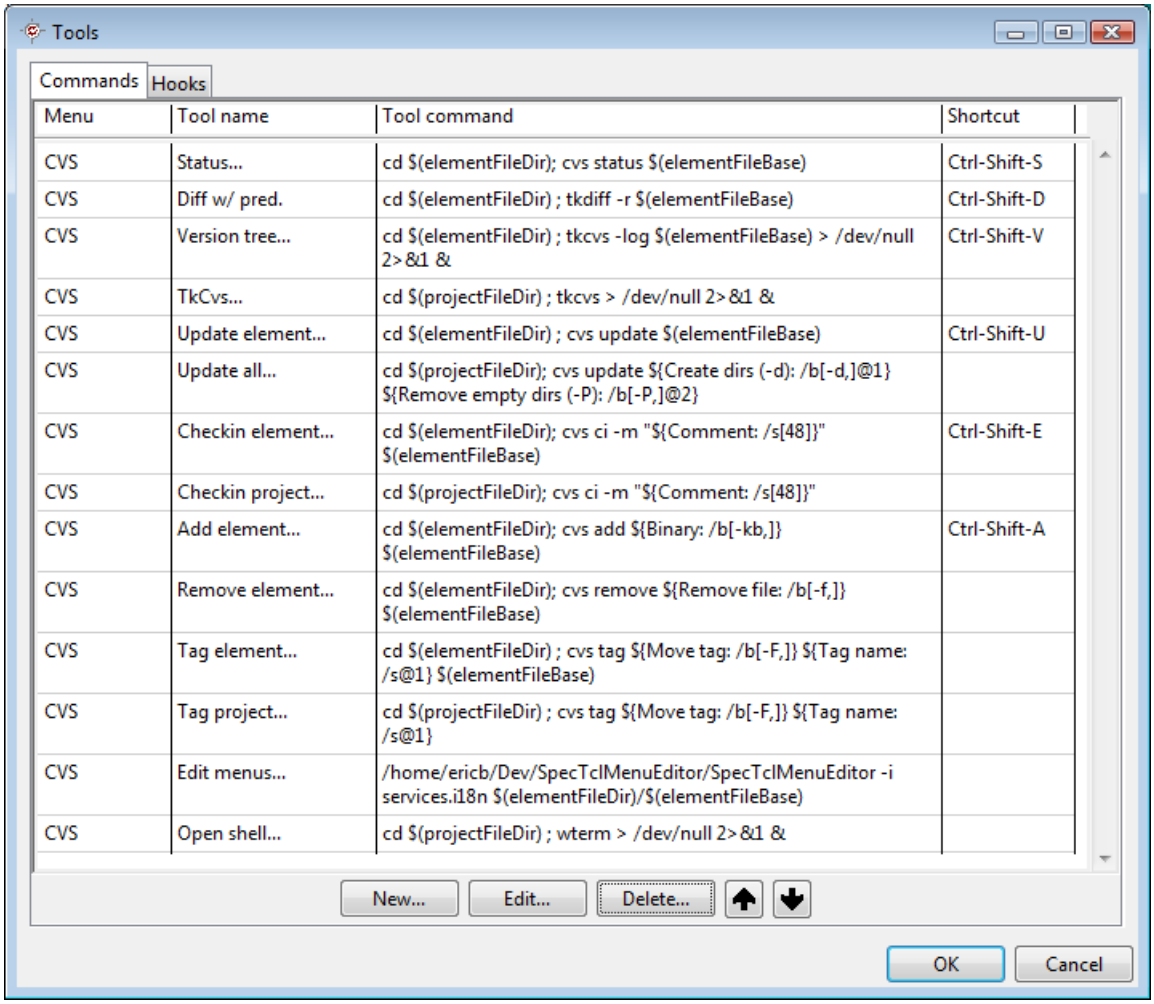


The columns are the name for the menu, the name of the menu item, the command to be run for the tool, which may include special markers (see “Tool commands” on page 34) and the shortcut for the item. Defining a new tool or editing an existing one opens the tool definition window:

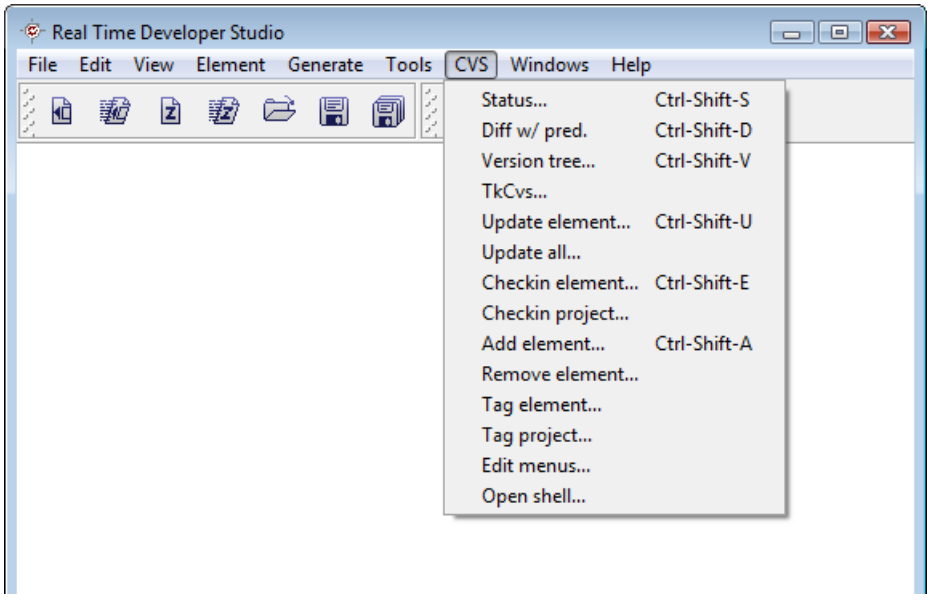


where these 4 fields may be entered or modified. The arrow buttons in the main tools window allow to reorder the tools in their menu.

Below is an example of a typical CVS menu:


Tools
Commands
Hooks
Menu
Tool name
Tool command
Shortcut
CVS | Status... | cd $(elementFileDir); cvs status $(elementFileBase) | Ctrl-Shift-S
CVS | Diff w/ pred. | cd $(elementFileDir) ; tkdiff -r $(elementFileBase) | Ctrl-Shift-D
CVS | Version tree... | cd $(elementFileDir) ; tkcvs -log $(elementFileBase) > /dev/null 2>&1 & | Ctrl-Shift-V
CVS | TkCvs... | cd $(projectFileDir) ; tkcvs > /dev/null 2>&1 & |
CVS | Update element... | cd $(elementFileDir) ; cvs update $(elementFileBase) | Ctrl-Shift-U
CVS | Update all... | cd $(projectFileDir); cvs update ${Create dirs (-d): /b[-d,]@1} ${Remove empty dirs (-P): /b[-P,]@2} |
CVS | Checkin element... | cd $(elementFileDir); cvs ci -m "${Comment: /s[48]}" $(elementFileBase) | Ctrl-Shift-E
CVS | Checkin project... | cd $(projectFileDir); cvs ci -m "${Comment: /s[48]}" |
CVS | Add element... | cd $(elementFileDir); cvs add ${Binary: /b[-kb,]} $(elementFileBase) | Ctrl-Shift-A
CVS | Remove element... | cd $(elementFileDir); cvs remove ${Remove file: /b[-f,]} $(elementFileBase) |
CVS | Tag element... | cd $(elementFileDir) ; cvs tag ${Move tag: /b[-F,]} ${Tag name: /s@1} $(elementFileBase) |
CVS | Tag project... | cd $(projectFileDir) ; cvs tag ${Move tag: /b[-F,]} ${Tag name: /s@1} |
CVS | Edit menus... | /home/ericb/Dev/SpecTclMenuEditor/SpecTclMenuEditor -i services.i18n $(elementFileDir)/$(elementFileBase) |
CVS | Open shell... | cd $(projectFileDir) ; wterm > /dev/null 2>&1 & |
New...
Edit...
Delete...
OK
Cancel

Once defined, the menus appear in the project manager window:



There is no way to control the order of the tool menus in the current version of RTDS.

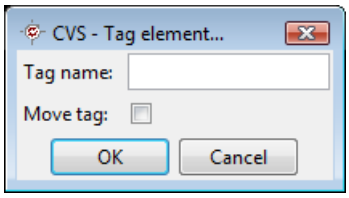
1.16.2 Tool commands

The tool commands are regular OS-dependent commands that will be executed via a shell or equivalent (`sh` on Unix, `command.com` or `cmd.exe` on Windows). These commands may however include special markers, allowing to get information from the current project, the currently selected element in the project manager, or from the user via a dialog box. These markers are:

- "`$(projectFile)`": this marker will be replaced by the opened project's full file name. If no project is opened, a message will be displayed and the tool command won't be executed.
- "`$(projectFileDir)`": same as `$(projectFile)`, but for the project directory.
- "`$(projectFileBase)`": same as `$(projectFile)`, but for the project file name without its directory.
- "`$(elementFile)`": this marker will be replaced by the full file name for the currently selected element in the project manager. If no element is selected, a message will be displayed and the tool command won't be executed.
- "`$(elementFileDir)`": same as `$(elementFile)`, but for the selected element directory.
- "`$(elementFileBase)`": same as `$(elementFile)`, but for the selected element file name without its directory.
- "`$(descendantElementFiles)`": this marker will be replaced by the list of all file names for the currently selected element and all its descendants. The file names will be separated by the standard path separator for the current platform (':' for Unix; ';' for Windows).
- "`${`*`<label>`*`/`*`<type>`*`[`*`<options>`*`]@`*`<order>`*`}`": this type of marker is used to ask information to the user before executing the command. All markers of this type will be used to build a dialog where the user may enter information before executing the command. The dialog will include one field per marker, built from the information between the braces in the marker:
  - "*`<label>`*" will be the text written before the field. It defaults to the empty string.
  - "*`<type>`*" is the field type. Today, two types are recognized: "`s`" for strings and "`b`" for booleans. The corresponding field type are a text entry and a checkbox respectively. The default type is string.
  - "*`<options>`*" are options for the chosen type. For strings, the only option is its length (default: 20). For booleans, options are the value when checked and the value when unchecked, separated by a comma. For example, a field with type "`b[-r,]`" will be replaced in the command by "`-r`" if the user checks the corresponding checkbox, and by the empty string otherwise. The defaults are "1" for checked and "0" for unchecked.
  - "*`<order>`*" is the order of the field in the dialog. If not set, the order will be chosen randomly. If set only for a subset of the fields, the ordered fields will always appear before the unordered ones.

  Example:
  If a tool command includes the following markers:
  - `${Tag name: /s@1}`
  - `${Move tag: /b[-F,]}`

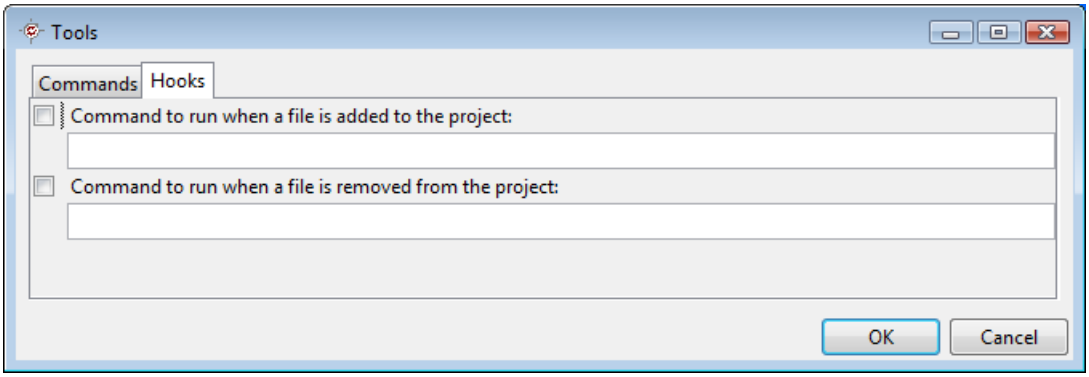
the following dialog will be built:



The "`${Tag name...}`" marker will be replaced by the contents of the "Tag name:" entry field in the dialog and the "`${Move tag...}`" marker will be replaced by "`-F`" if the checkbox is checked and by the empty string otherwise.

1.16.3 Hooks addition and removal

RTDS allows to automatically call a command when an element is added or removed from the opened project. These "hooks" are configured in the external tools management dialog in *File / Tools / Configure...* and *Hooks* tab:



The syntax for the hook commands is the same as the one for the regular tool commands.

Please note that if the command contains user-defined variables (`${...}`) and if several files are added or removed in a single operation, the value for the variables will only be asked once and applied to all added or removed files.

1.17 - Traceability information

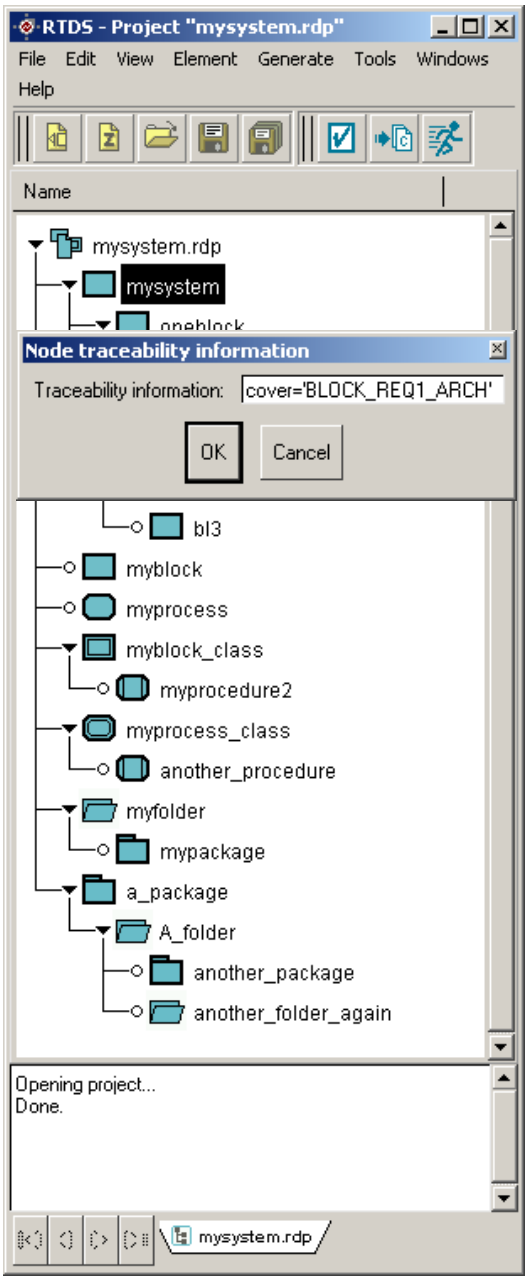
1.17.1 Scope

Traceability information can be defined on any element of the *Project manager*. These informations can be used in a traceabilitity informations tool in order :

- to manage requirements,
- to analyze the impact of modifications.

1.17.2 Traceability editor

To add traceability information, select a node in the *Project manager* and go to the menu *Element / Traceability information* :



The traceability information is stored in the XML RTDS project file (.rdp) as the attribute `traceabilityInfo` of the node tag.

1.17.3 Integration with Reqtify

1.17.3.1 Organisation

An integration with Reqtify traceability tool is delivered with RTDS. This integration is composed of the following files :

- `rtds.br` : RTDS behavior file,
- `rtds.types` : RTDS type file,
- `pragma.bmp` : PragmaDev logo,

- `rtds_block.bmp` : Block diagram logo,
- `rtds_block_type.bmp` : Block class diagram logo,
- `rtds_class.bmp` : Class diagram logo,
- `rtds_codecov.bmp` : Code coverage logo,
- `rtds_compstate.bmp` : Composite state diagram logo,
- `rtds_depl.bmp` : Deployment diagram logo,
- `rtds_document.bmp` : Document logo,
- `rtds_file.bmp` : File logo,
- `rtds_folder.bmp` : Folder logo,
- `rtds_hmsc.bmp` : HMSC logo,
- `rtds_macro.bmp` : Macro logo,
- `rtds_msc.bmp` : MSC logo,
- `rtds_package.bmp` : Package logo,
- `rtds_procedure.bmp` : Procedure diagram logo,
- `rtds_process.bmp` : Process diagram logo,
- `rtds_process_type.bmp` : Process class diagram logo,
- `rtds_project.bmp` : RTDS Project logo,
- `rtds_protogui.bmp` : Prototyping logo,
- `rtds_service.bmp` : Service diagram logo,
- `rtds_system.bmp` : System diagram logo,
- `rtds_use_case.bmp` : Use case diagram logo,
- `rtdsRDP2Text4Reqtify.exe` : Stand alone program that extracts information from RTDS project file and generates an information file readable by Reqtify.

1.17.3.2 Installation for Reqtify before version 4.0

This paragraph make the assumption that the Reqtify toolset is installed in `%REQTIFY_HOME%` directory. The procedure is to copy the files:

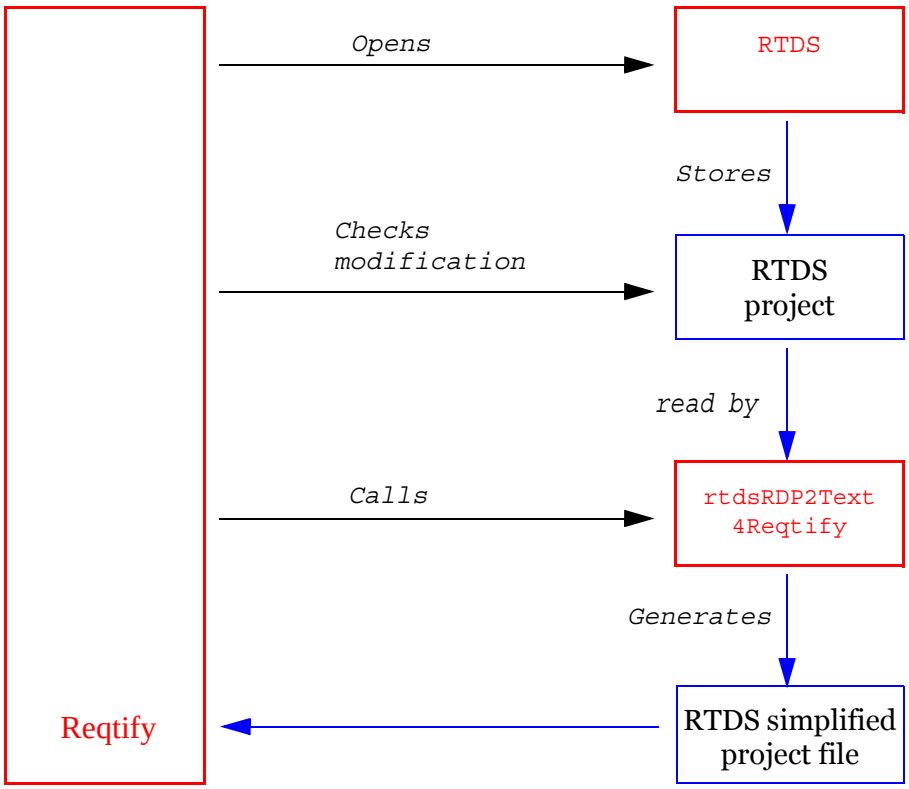
- `rtds.br`
  from `%RTDS_HOME%\share\3rdparty\Reqtify\`
  to `%REQTIFY_HOME%\config\otscript`
- `rtds.types`
  from `%RTDS_HOME%\share\3rdparty\Reqtify\`
  to `%REQTIFY_HOME%\config\types\design`
- `All bmp files`
  from `%RTDS_HOME%\share\3rdparty\Reqtify\`
  to `%REQTIFY_HOME%\config\images`

`rtds.types` defines

- the new *PragmaDev RTDS* type of analysis,
- how to handle an RTDS project : in that integration Reqtify is told via the `rtds.br` behavior file to call the `rtdsRDP2Text4Reqtify.exe` program that will generate an information file understandable by Reqtify,
- how to analyse the generated file with coverage and requirement information.

1.17.3.3 General architecture

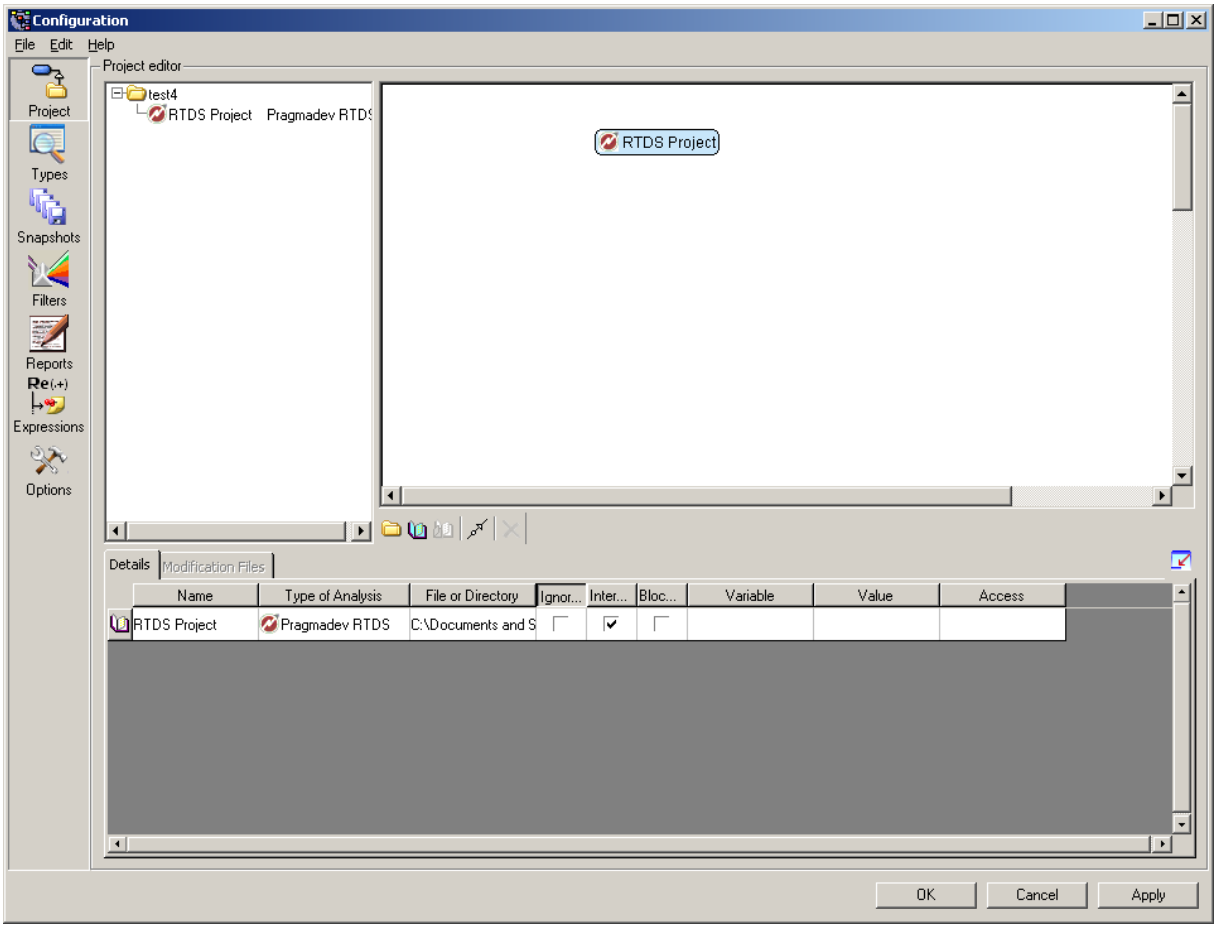
Reqtify relies on these previously installed files to work as described in the following diagram:



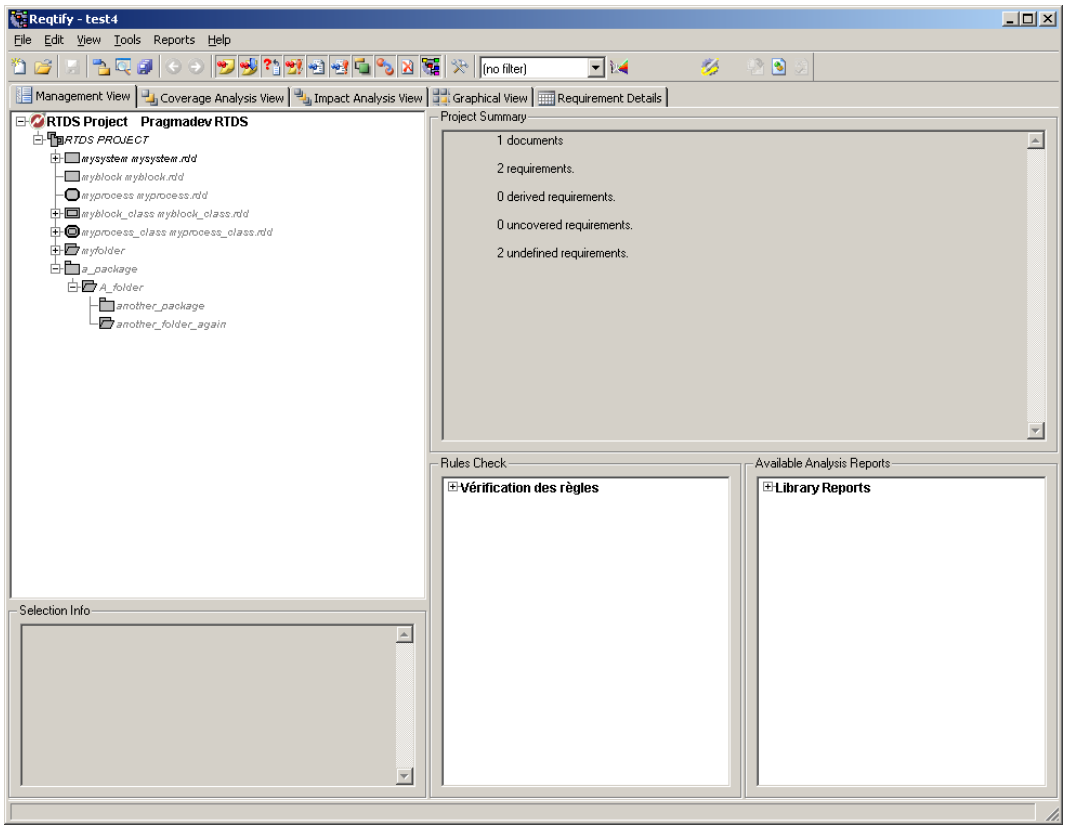
An RTDS diagram can be opened directly from Reqtify. Reqtify also checks if the RTDS project file has been modified. If the file has been modified, it calls `rtdsRDP2Text4Reqtify` utility that generates a project file understandable by Reqtify.

1.17.3.4 Usage

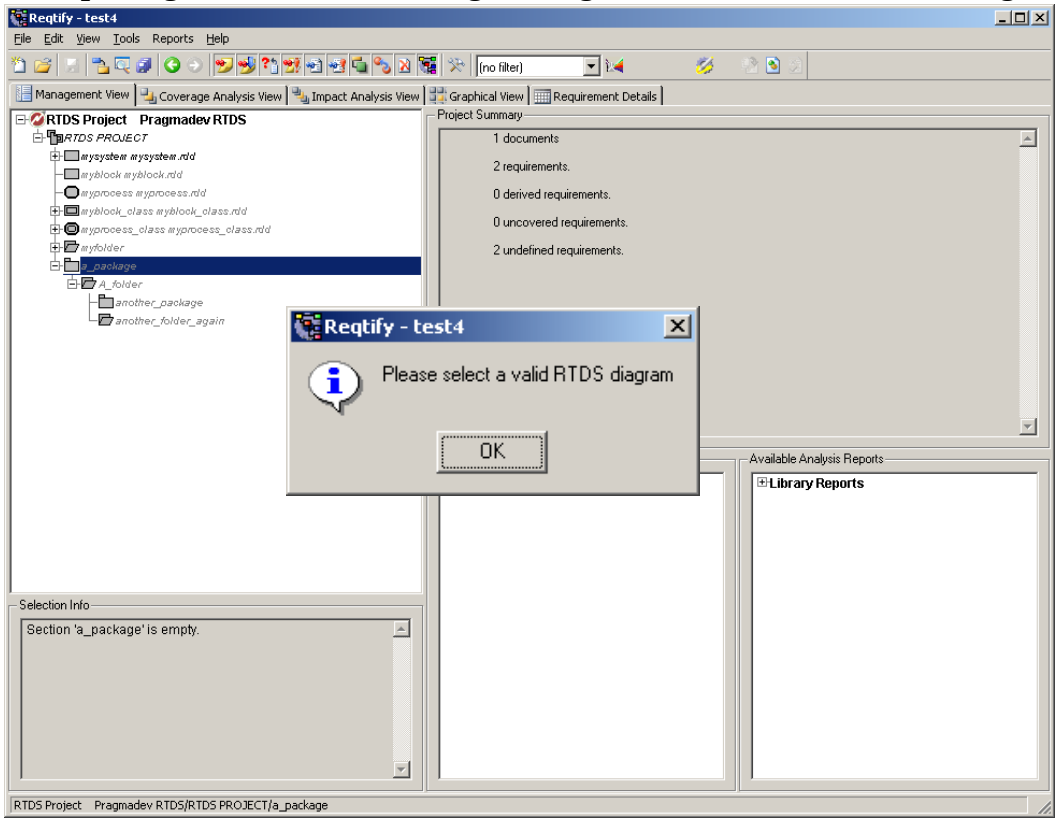
It is now possible to add an RTDS project into Reqtify and to set its type to *PragmaDev RTDS* as shown below :



Click Ok and Reqtitfy will display the RTDS project architecture as shown in the example below :



Clicking on an element of the RTDS project will open that element in RTDS. If not a valid component (package or folder) a warning message will ask to select a valid diagram.

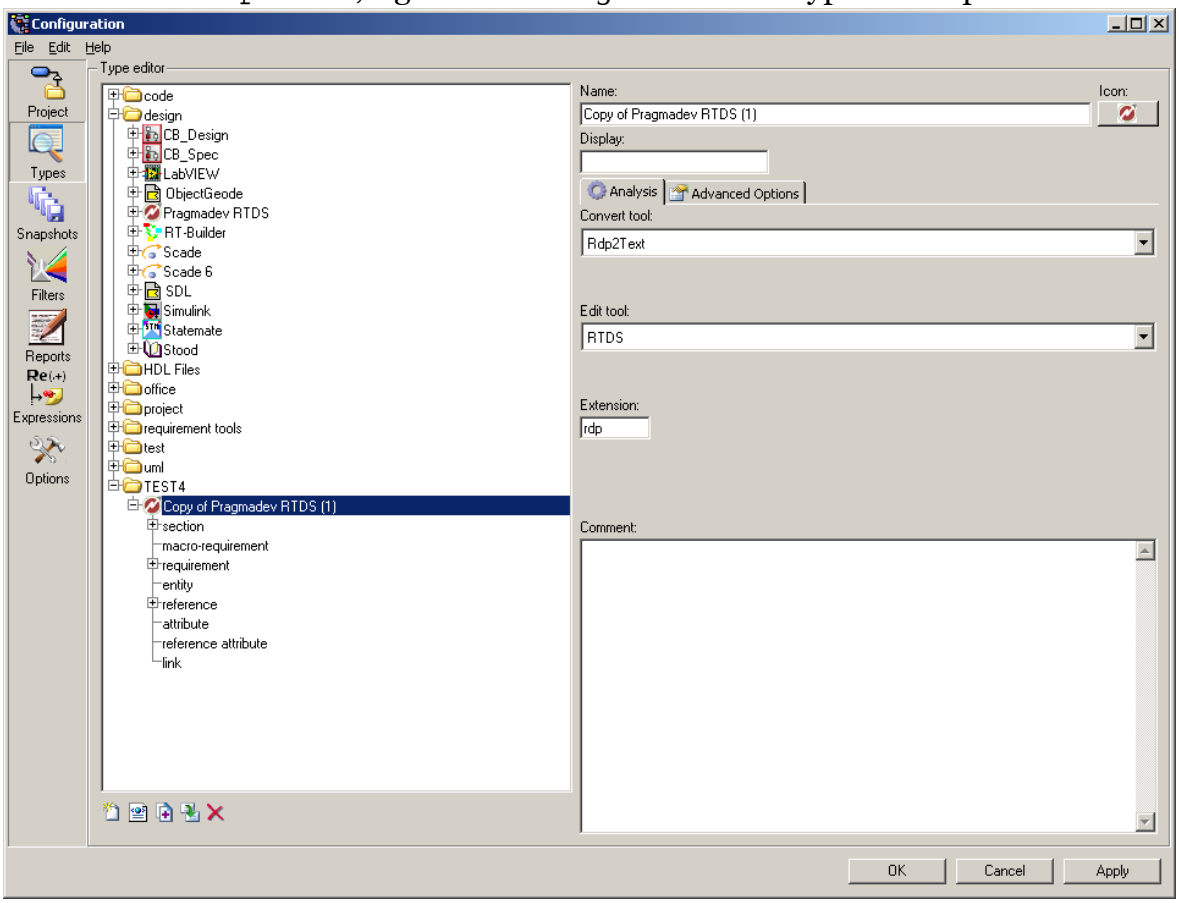


1.17.3.5 Format of traceability information

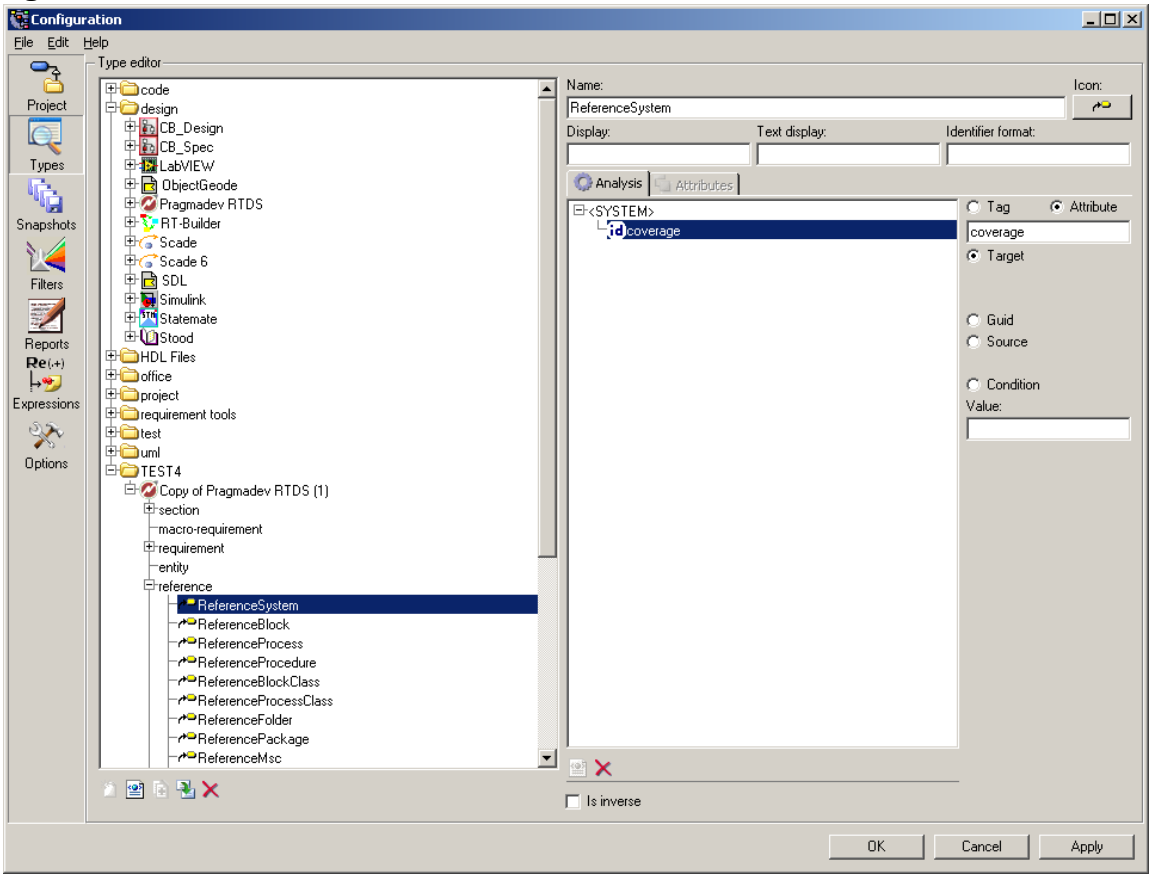
By default the traceability information for all component has the following format :

```
cover='<REQUIREMENT_IT_COVER>' require-
ment='<REQUIREMENT_TO_COVER>'
```

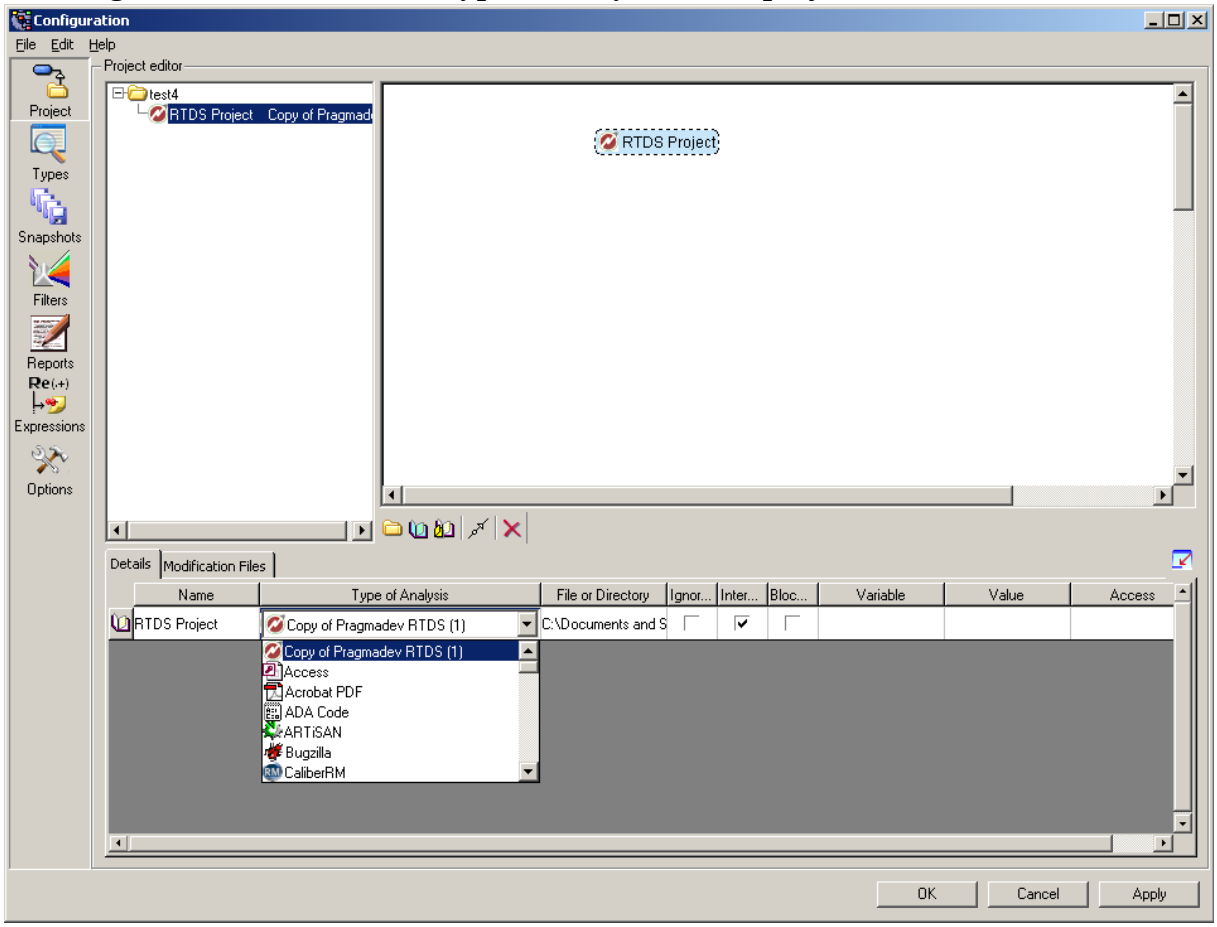
This can be customized with Reqtify type editor. For example would you like the traceability information to have the format `coverage='<REQUIREMENT_IT_COVER>' for the SYSTEM component`, right clik on *PragmaDev RTDS* type and duplicate it :



Open the reference section of the SYSTEM component named ReferenceSystem to change the name of the attribute as shown below :



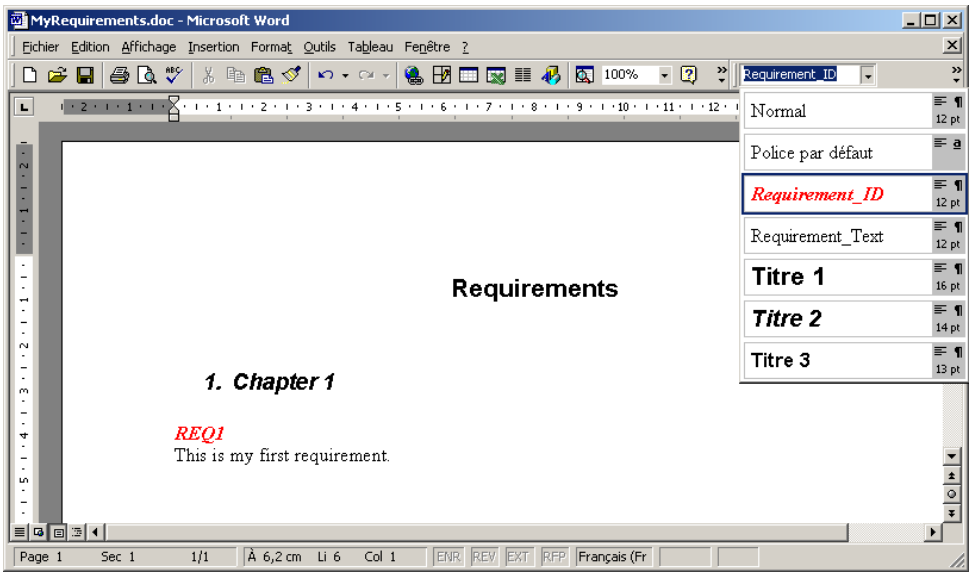
Before validating this new type, the project editor needs to know that the type of analysis has changed. To do so select this type of analysis in the project editor and click OK :



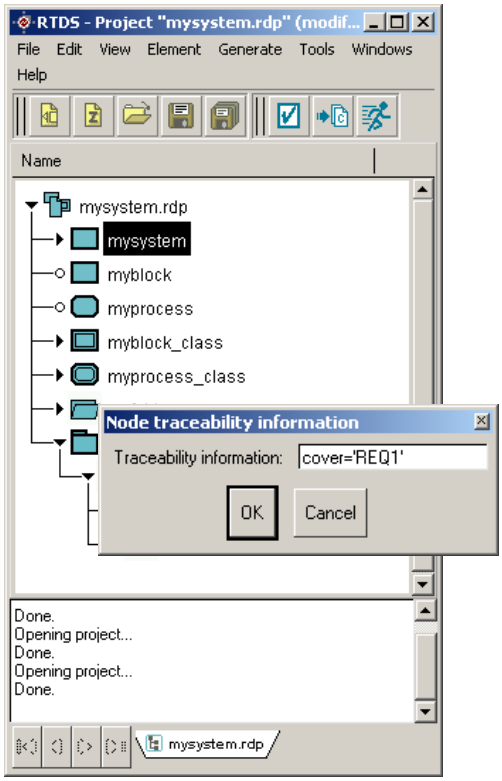
1.17.3.6 Example

The following example creates a link from a Word document to an RTDS Project with the default Reqtify syntax.

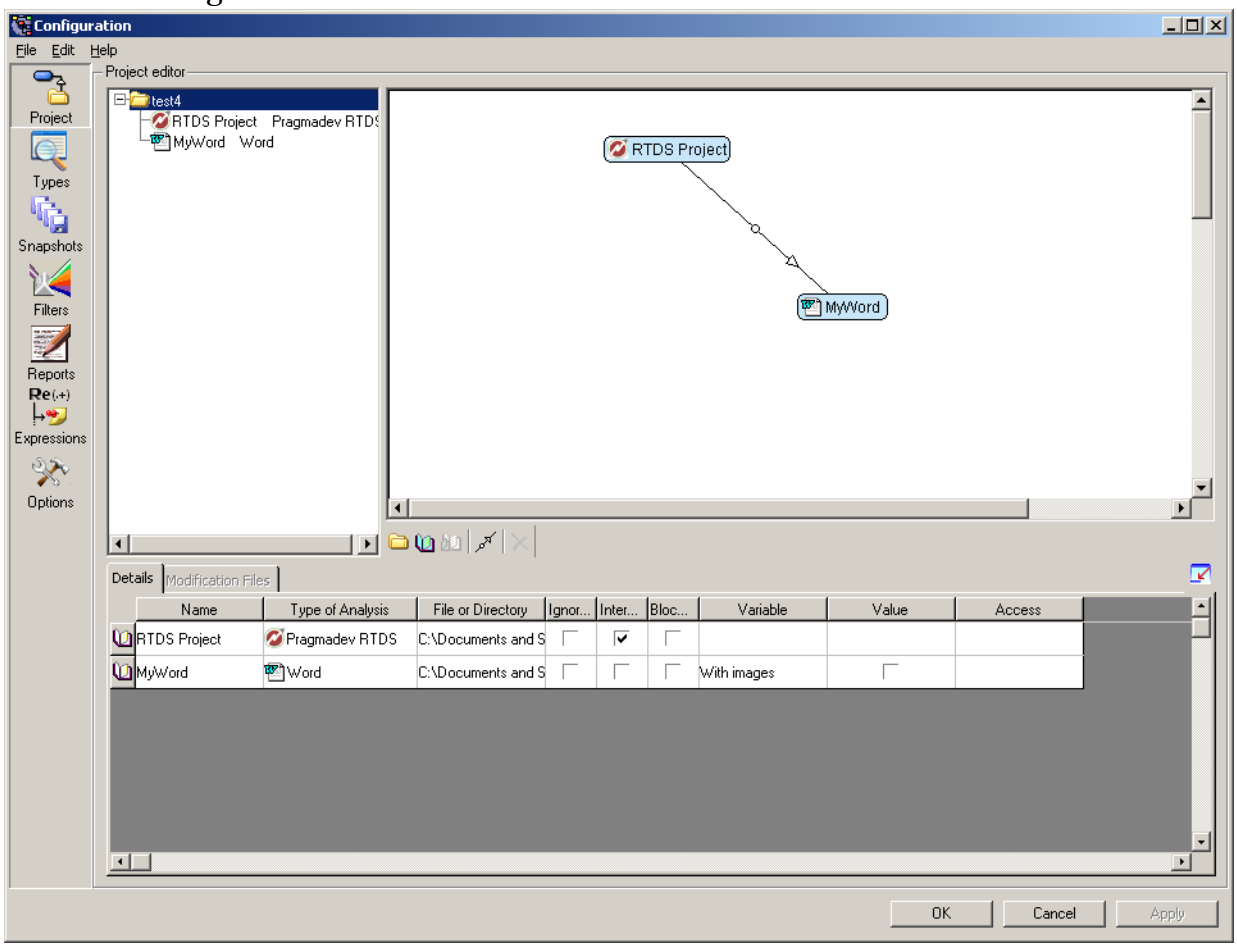
In a Word document, the requirement identifier `REQ1` is defined with *Requirement_ID* style.



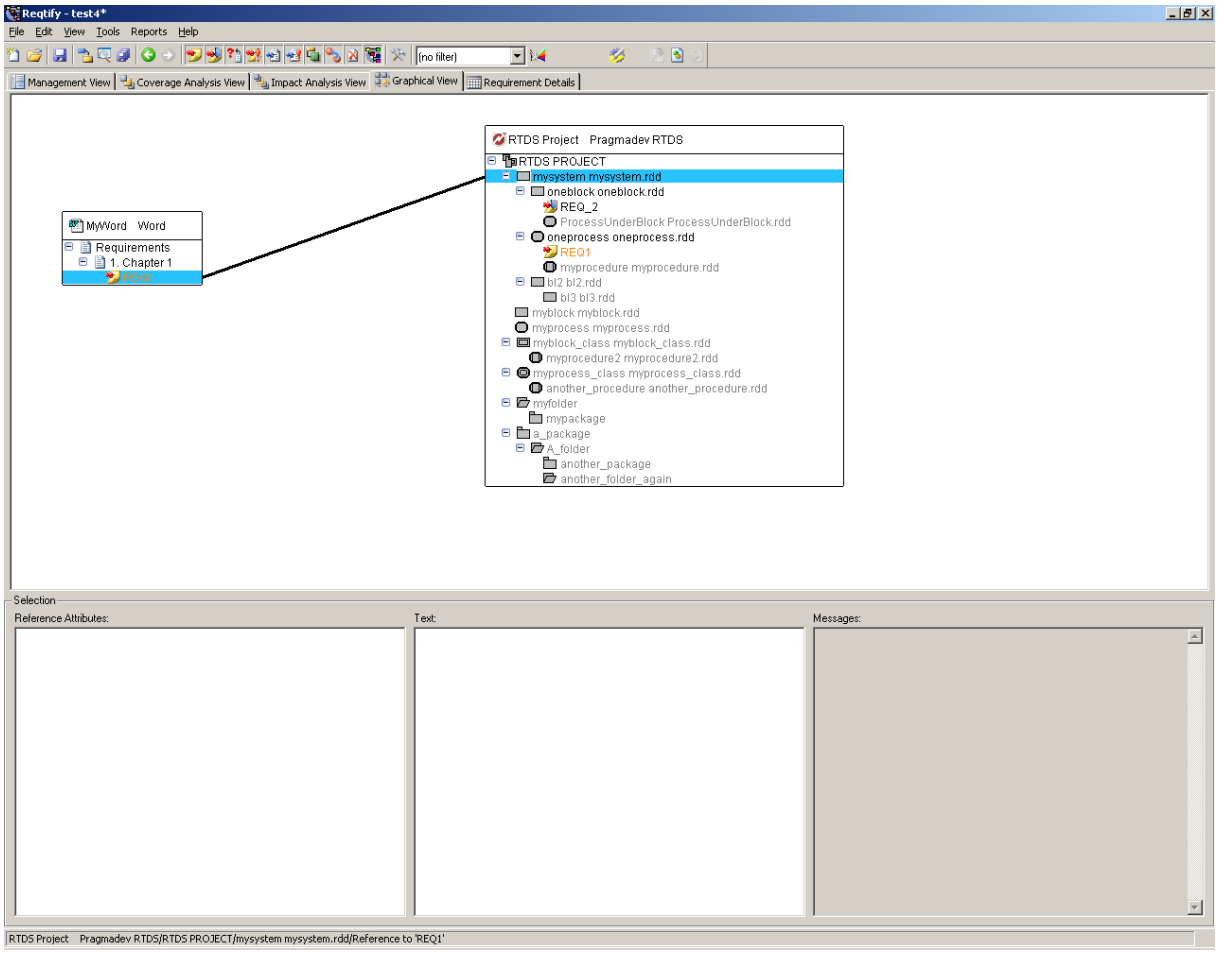
Within RTDS select the element covering the requirement and go to the *Element / Traceability information...* menu. In the *Node traceability information* popup window, indicate which requirement is covered.



Add both documents in the Reqtify Project Editor with their respective analysis type and create a coverage link from one document to the other :



After analysis, Reqtify will show the links in the Graphical View editor :



2 - Diagram editor

The diagram editor is the window where all types of diagrams may be edited. The editor window is the same for all types of diagrams, and its basic features are the same. It may however have a few extra features depending on the type of the displayed diagram.

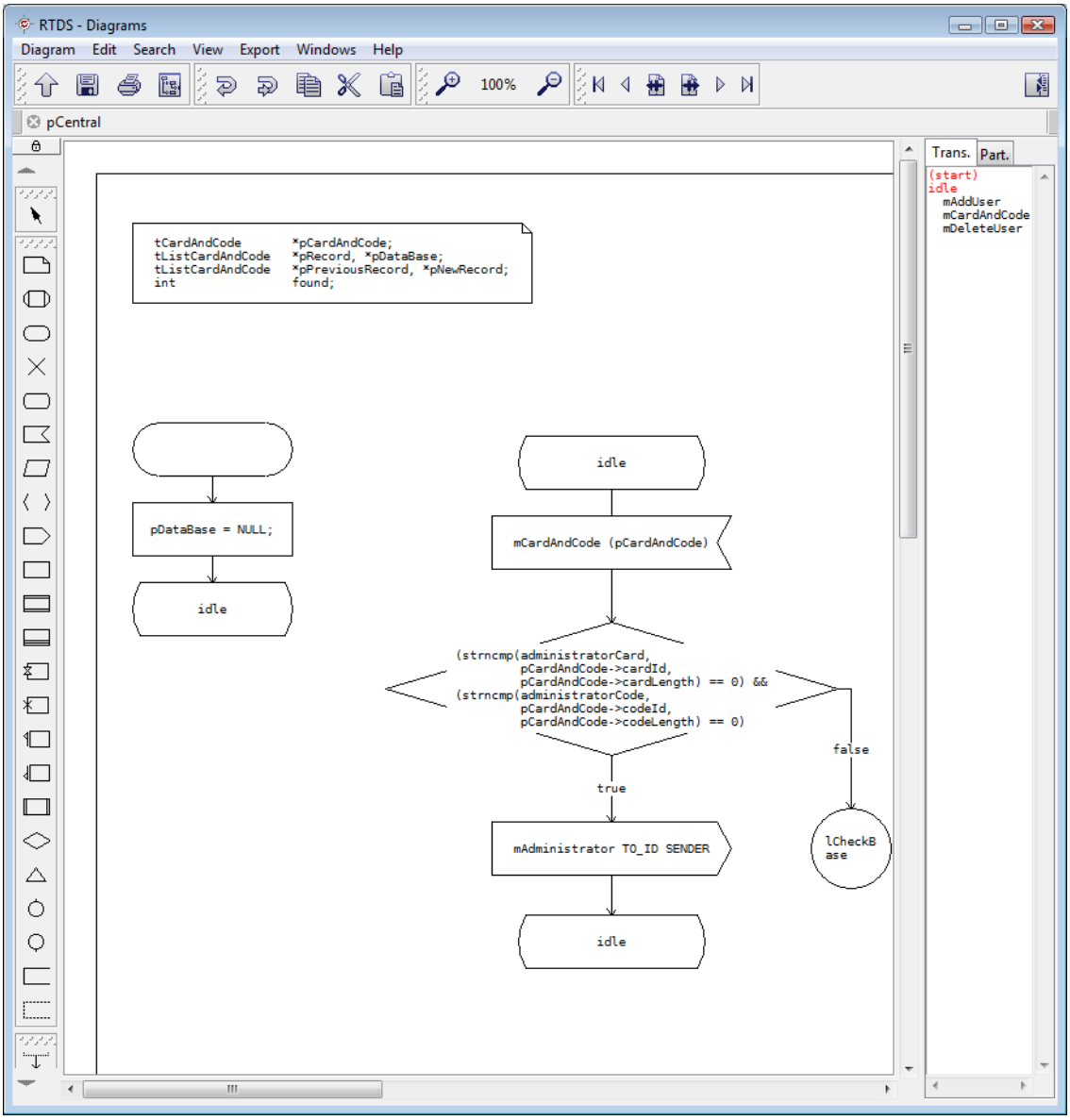


Diagram editor window

2.1 - Common features

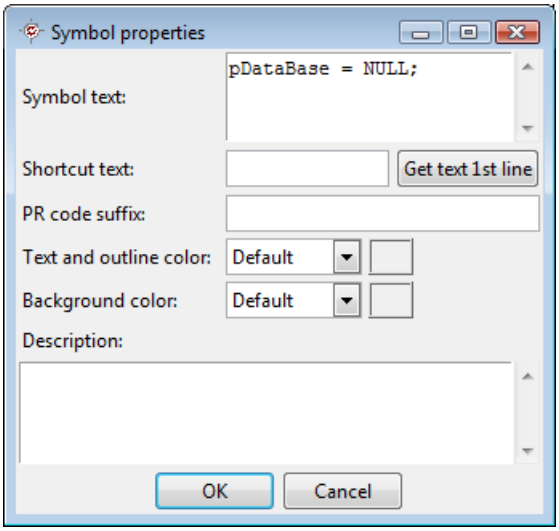
2.1.1 Frame concept

All diagrams have a surrounding frame, containing all the symbols in the diagram. You can't put symbols outside that frame. For SDL system and block diagrams, the frame also represents the external boundary of the agent, and channels may be connected to it.

2.1.2 Symbol and link properties

Each symbol or link has a property sheet allowing to enter all its features in a guided way. The actual properties depend on the type of the symbol or link. It may be opened by selecting a symbol or link and choose "Properties..." in the contextual menu.

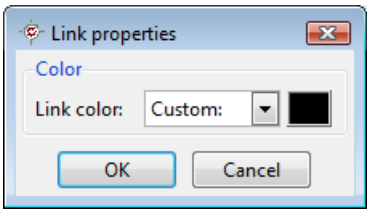
The basic property sheet for a symbol is the following:



- The symbol text is the one that normally appears in the text.
- The symbol shortcut text may be used to specify an alternate text to display in the symbol and to open its "real" text in an external editor. It may be used for symbols with a very long text to avoid taking too much space in the diagram. If this shortcut text is set, it will appear underlined in the diagram:

  Double-clicking on the symbol shortcut text will open the external editor showing the symbol actual text.
- The PR code suffix is available for all symbols but is only meaningful for symbols declaring a SDL agent. This text will be inserted after the agent declaration in exported PR files whenever the actual agent is not defined. This is used to keep Geode-style external references in RTDS diagrams; It should usually be left empty.
- The colors are the color for the symbol's text and outline and the color for its background.
- The symbol description is only used for documentation purposes.

The default property dialog for a link only includes its color:



Please refer to the paragraphs describing the editors for examples of property sheets for specific link types.

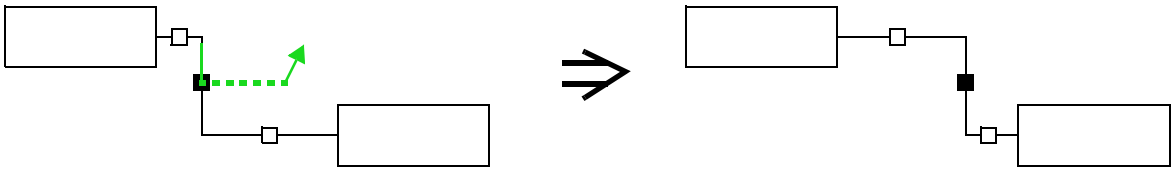
2.1.3 Moving symbols

The symbols in a diagram may be moved by using the mouse or via the arrow keys: if a group of symbols is selected, pressing the arrow keys will move the symbols by one grid cell. Pressing the arrow keys while maintaining the Control key pressed will move the symbols by one point.

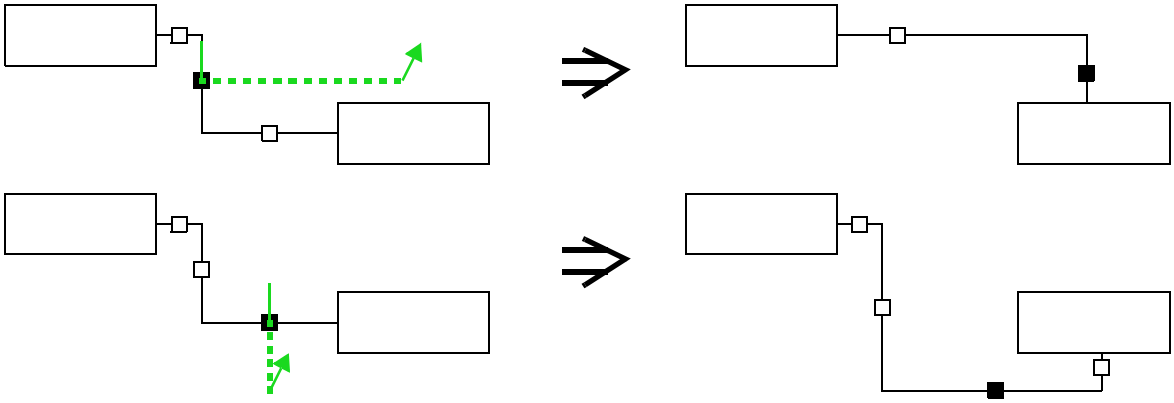
2.1.4 Modifying links

There are two ways of modifying existing links in the diagram editor:

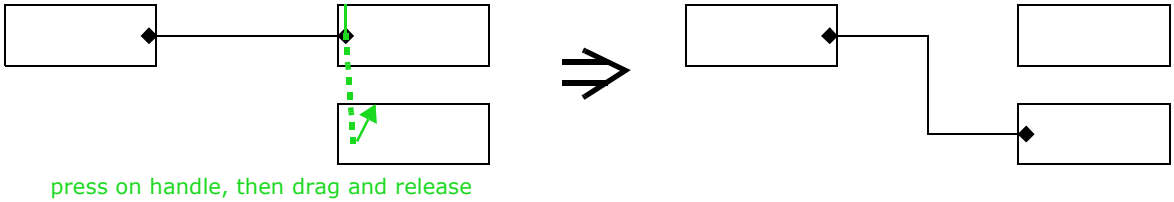
- For broken links, the segments may be moved by using the handle appearing in the segment middle:



If needed, segments will be automatically created or deleted:



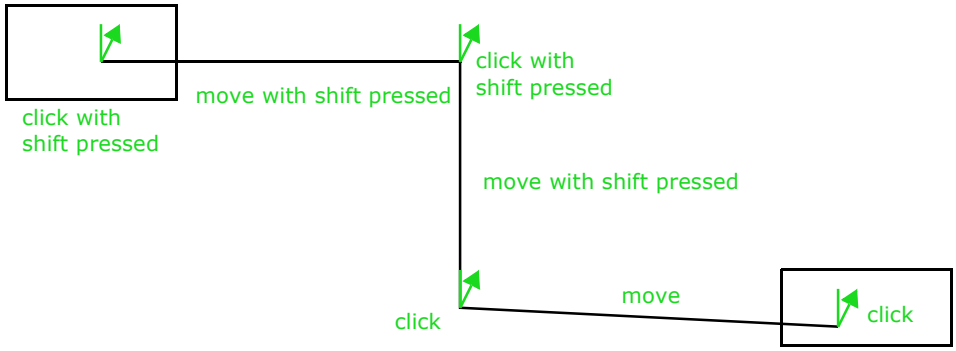
- For all links, diamond-shaped handles at both ends allow to change the symbol to which the link connects:



2.1.5 Button and tool bars

As seen in the screen shot above, the diagram editor window has several button bars and tool bars. The button bars give access to all usual operations. The tool bars are at the left of the window and are separated in 3 parts:

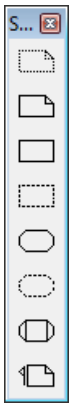
- The top tool bar gives access to the general operations on the contents of the diagram. It's usually restricted to the selection tool, but MSC diagrams have a few extra tools (see "Specific tools" on page 70).
- The middle tool bar is the symbols tool bar. It allows to insert new symbols in the diagram. This insertion is made by clicking on the button corresponding to the symbol you want to insert, then clicking within the diagram's frame where you want to insert the symbol.
- The bottom tool bar is the links tool bar. It allows to insert new links between symbols within the diagram. There is a button for each link type allowed in the diagram. Make sure you select the right type for the symbols you want to link, or the insertion may be refused.
  The link insertion is made by clicking on the button corresponding to the link type you want to insert, then pressing the mouse button over the first symbol and dragging to the other symbol. If you want to manually indicate a path between the two symbols, shift-click on the first symbol, then shift-click on each corner for the link. Holding the shift key allows to restrict the move to horizontal or vertical lines. For example:



Above the toolbars is a tiny lock icon that looks like this: . When this icon is not active, the button inserts a single symbol or link: once one symbol or link has been inserted, the editor returns to selection mode. Clicking once on the icon makes it active. After that, any insertion button will be "sticky": any number of symbols or links may be inserted in a row. To go back to "non-sticky" mode, press the lock icon again or select the selection tool.

The button and tool bars have a common aspect and behavior: Both have a header looking this: . It is at the left for button bars and at the top for tool bars. By clicking on this

header and dragging it away, the bar can be detached from its parent window and displayed in its own window.



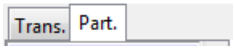
Symbol tool bar for blocks

To put the tool bar back in its parent window, just close the tool bar window.

2.1.6 Partitions

Large diagrams can be split into partitions. A partition is a set of pages that may contain any number of symbols and links. Partitions may be added, deleted and printed via the "Diagram" menu.

Navigating through partitions can be done by using the left-most toolbar in a diagram window or with the partition browser, displayed at the right of the diagram. If several browsers are available, the partition browser can be selected via the "Part." tab at the top of the browsers:

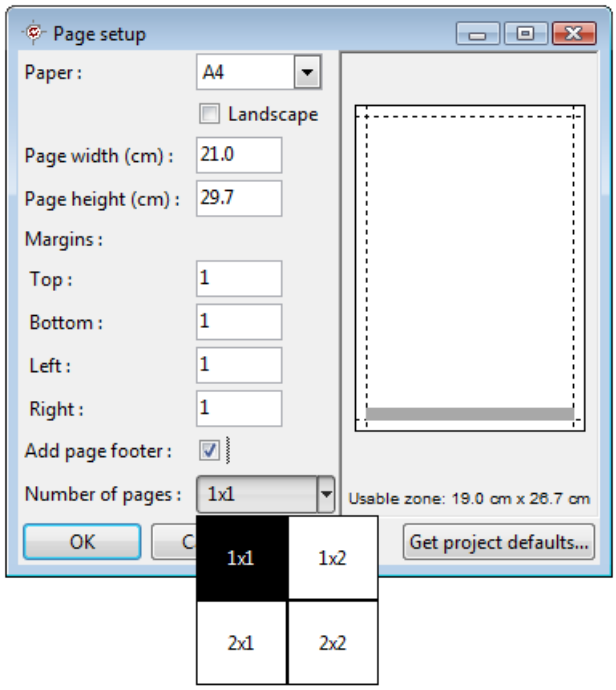


Notes:

- A partition can only be deleted if it doesn't contain any symbol or link.
- Partitions are not available in MSC diagrams.

2.1.7 Page setup

To ensure a WYSIWYG behavior, all partitions in a diagram include a page setup that will be the one used when printing it. This page setup may be edited via the "Partition page setup..." item in the "Diagram" menu in diagram editors. The following dialog appears:



The fields "*Paper*", "*Landscape*", "*Page width (cm)*" and "*Page height (cm)*" are used to specify the paper size. The "*Margins*" are automatically removed from the usable area for the partition and when printing. If the "*Add page footer*" option is checked, a footer will be displayed on each printed page, containing the name of the printed file and the page number. The height of this footer is also removed from the usable area for the diagram. This usable area is displayed with its dimensions in the right part of the dialog.

The field "*Number of pages*" one is used to specify the number of rows and columns of pages in the diagram.

A default page setup can be configured in the project manager (menu "File", "Page setup..."). Clicking the button "Get project defaults" in any page setup dialog will select this default page setup.

There is a shortcut to add a row or column of pages in diagrams: along each side of the edge pages, the following buttons appear:

These buttons will add a page column or row to the diagram respectively.

2.1.8 Publications

It is possible to attach to any diagram a set of publications. A publication is a set of symbols that will be exported as one or several external image file(s). These publications are

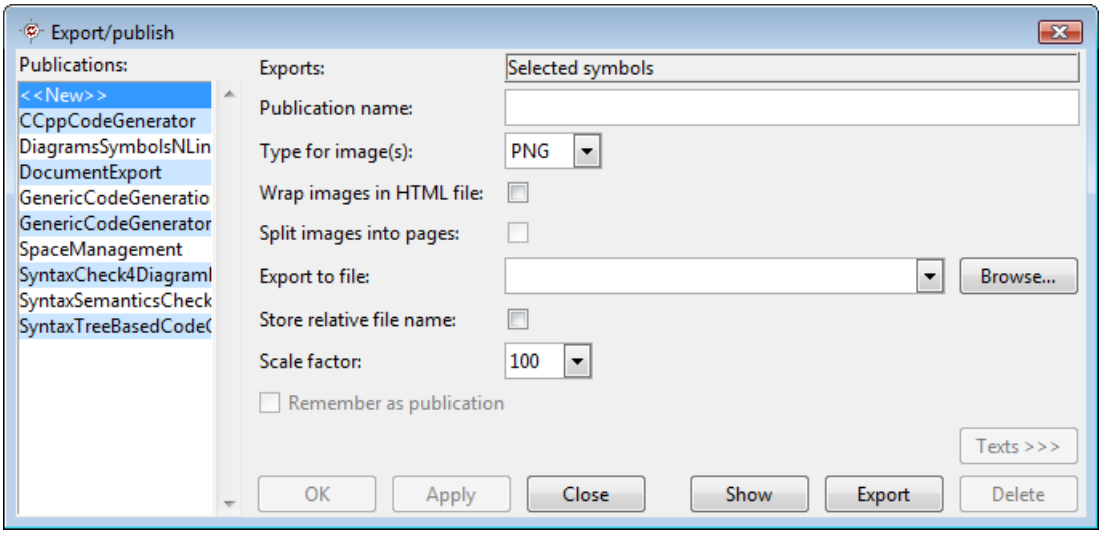
dynamic: the set of exported symbols is remembered and you can re-export them at any time, or ask to have them exported automatically when you save the diagram (see paragraph about diagram preferences in “PR (Phrasal Representation) and CIF (Common Interchange Format) files are ITU-T standards to exchange SDL models from one tool to another. RTDS allows to import a file in SDL PR/CIF format to a RTDS SDL project file. This is done via the "Import PR/CIF file..." item in the "Project" menu. The import configuration is made via a wizard; The panels in this wizard are described in the following paragraphs.” on page 15).

These publications can be used by importing them in any word processing software that has an "insert with link" or "import by reference" function. This function allows to insert a file into the current document, but keeps a reference to the inserted file so that any modification to the inserted file will be reflected automatically in the document. Since RTDS will update the publications after each diagram modification, it will ensure that the contents of the document importing them will always be up to date.

There are currently 5 types of publications:

- Symbol publications will export a set of given symbols;
- Transition publications will export all symbols in a given transition, identified by its state and message input or continuous signal;
- State publications will export all symbols in all transitions attached to a given state symbol;
- Partition publication will export a whole partition;
- Diagram publications will export the whole diagram.

These publications are available via the entries "Export/publish ..." in the "Export" menu in diagram editors. All these entries open the following dialog:

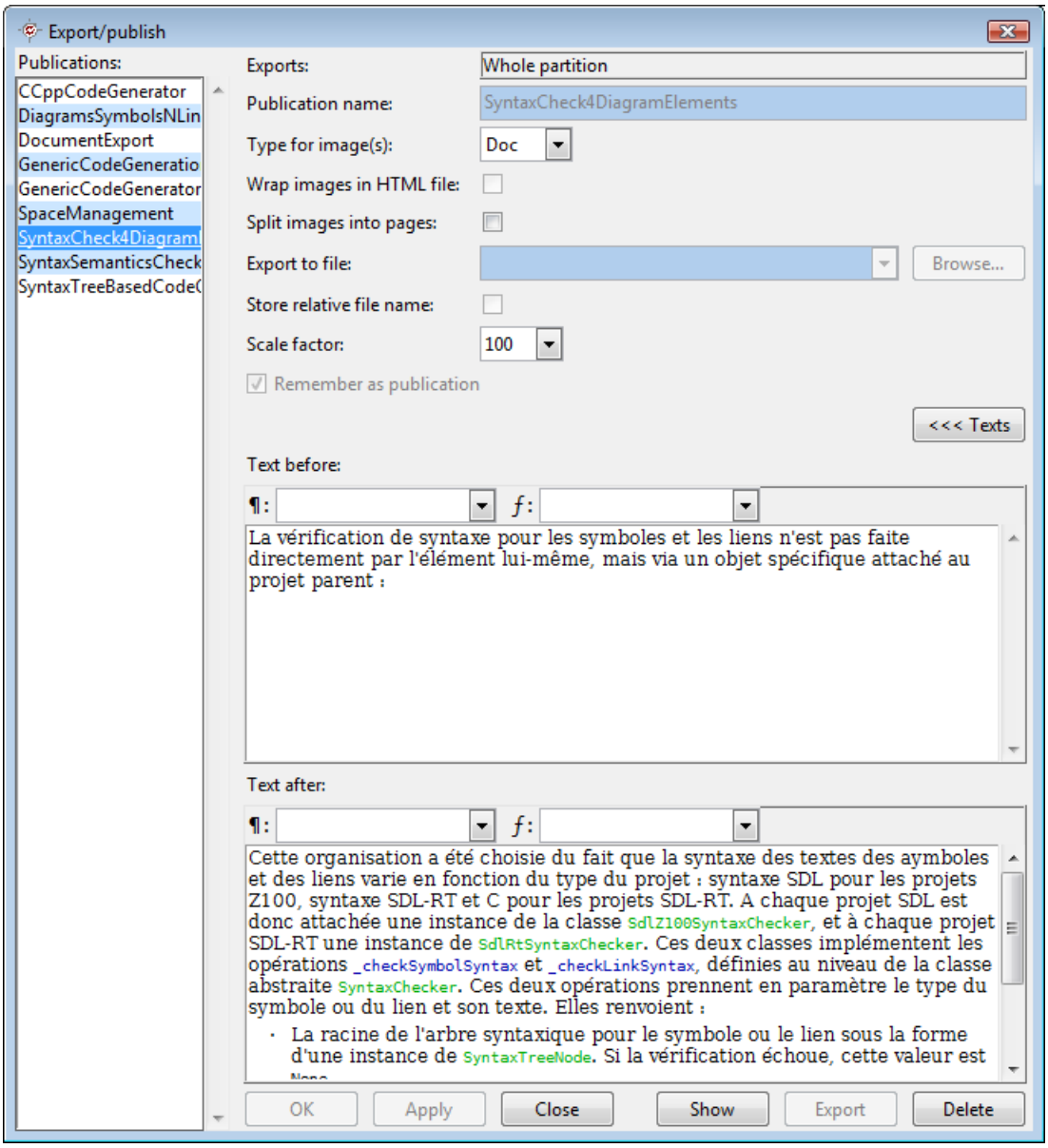


The dialog allows to set:

- The name for the publication if any. When doing a simple export, this field does not need to be filled.
- The type for the exported image(s): PNG, JPEG, EPS for Encapsulated Postscript or CGM. Another type named ’Doc’ is also available. It should be used for publications that are only used in RTDS documents. These kind of publications don’t actually export anything until the document they’re included in is itself exported to a given format. For more information, see “Document editor” on page 91.

- Whether the exported image(s) should be wrapped in a HTML file. This should be used if the publication consists in several images or pages. Importing the HTML file in a word processing software allows to import the whole set of images in one operation, and to keep it up to date even if the grows or shrinks afterwards. Note that this option should only be used for PNG or JPEG images, as browsers usually can't display Encapsulated Postscript or CGM images.
- For partition and diagram publications, each exported image contain by default a whole partition. Checking the "*Split images into pages*" option allows to export an image per printed page in the diagram or partition.
- The file name for the exported image; please note a suffix can be added to this name if the publication exports several images.
- Whether the file name for the publication should be remembered as an absolute pathname, or relative the the diagram file name.
- The zoom factor applied before exporting.
- Whether the exported images should be remembered in a publication or not. If the option is not checked, the export will be done one time, but not kept up to date with the diagram.

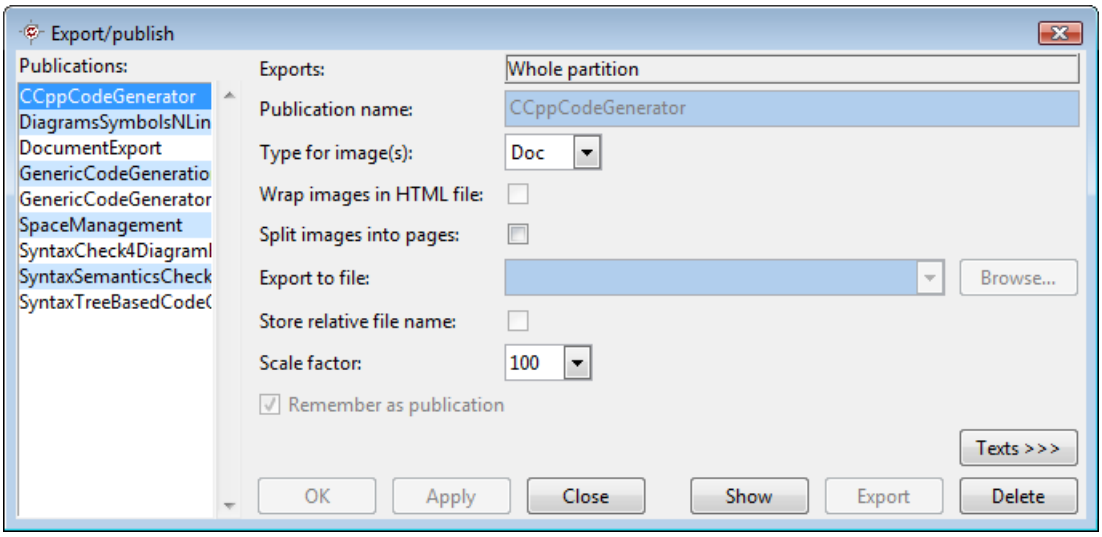
The 'Texts >>>' button allows to associate texts with the publication. Clicking on it changes the dialog to show two text editors:


Export/publish
Publications:
CCppCodeGenerator
DiagramsSymbolsNLin
DocumentExport
GenericCodeGeneratio
GenericCodeGenerator
SpaceManagement
SyntaxCheck4Diagraml
SyntaxSemanticsCheck
SyntaxTreeBasedCode(
Exports:
Whole partition
Publication name:
SyntaxCheck4DiagramElements
Type for image(s):
Doc
Wrap images in HTML file:
Split images into pages:
Export to file:
Browse...
Store relative file name:
Scale factor:
100
Remember as publication
<<< Texts
Text before:
La vérification de syntaxe pour les symboles et les liens n'est pas faite directement par l'élément lui-même, mais via un objet spécifique attaché au projet parent :
Text after:
Cette organisation a été choisie du fait que la syntaxe des textes des aymboles et des liens varie en fonction du type du projet : syntaxe SDL pour les projets Z100, syntaxe SDL-RT et C pour les projets SDL-RT. A chaque projet SDL est donc attachée une instance de la classe SdlZ100SyntaxChecker, et à chaque projet SDL-RT une instance de SdlRtSyntaxChecker. Ces deux classes implémentent les opérations _checkSymbolSyntax et _checkLinkSyntax, définies au niveau de la classe abstraite SyntaxChecker. Ces deux opérations prennent en paramètre le type du symbole ou du lien et son texte. Elles renvoient :
La racine de l'arbre syntaxique pour le symbole ou le lien sous la forme d'une instance de SyntaxTreeNode. Si la vérification échoue, cette valeur est
OK
Apply
Close
Show
Export
Delete

These editors are used to create or edit the styled texts that will automatically appear before and after the publication image when included in a document. For more information, see “Styled text editor” on page 101.

The list in the left part of the dialog contains the names for the already existing publications. Clicking on one of the names will display the attributes for the publication in the dialog as in the "Manage publications" dialog. It is possible to go back to the current one by clicking the '<<New>>' entry, which is always the first in the list. The actual export is done by clicking 'Apply' or 'OK'.

The last item in the "Export" menu is named "Manage publications..." and opens the same dialog as above, except it won't show a '<<New>>' entry:



The zone in the dialog's left part lists the names for all publications in the current diagram. Clicking on one of the names will display the publication attributes in the right part, and allows to change some of them. The 'Show' button will display the exported part of the diagram; The 'Export' button allows to explicitely update an existing publication.

Notes:

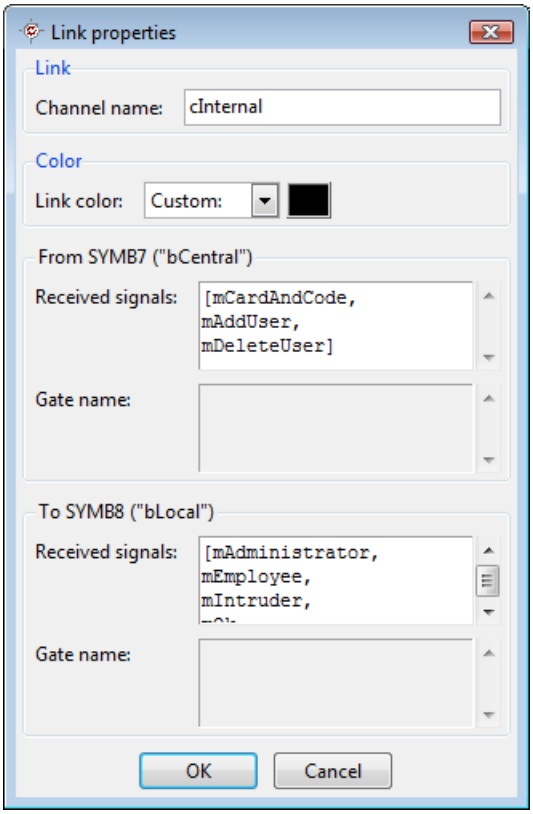
- When saving a diagram having publication, a dialog may appear asking whether to update the publications. This behavior is controlled by the "Update publication" option in the diagram preferences (see "Diagram preferences" on page 26).
- On Windows, the selected symbols may also be directly copied to the Windows clipboard by using the item "Copy as bitmap" in the "Edit" menu (shortcut: Shift-Ctrl-C). This feature is not available on Unix platforms.
- The publications may also be used in documents written using a markup language like SGML, XML or HTML. For example, with HTML, images may simply be imported via the tag `<img src="">` without giving any dimension for the image so that they will always be read from the image file.
- Some word processors (e.g. FrameMaker) remember the size you gave to any imported graphics, even if these were imported by reference. RTDS publications still work with these, but you may end up with distorted graphics in the final document if the size of a publications changes.

2.2 - SDL editor features

2.2.1 Link properties

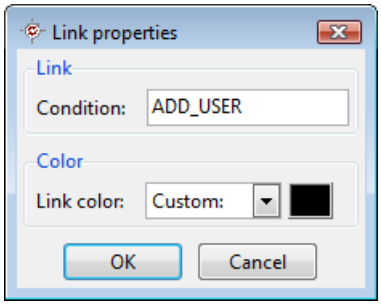
The following link types have specific property dialogs:

- Channels in system or block diagrams have the following property dialog:



  The dialog allows to modify the channel name and for either end of the channel, the received signals and the gate name if available. The gate name is available only if the symbol is a block or process class instance.

- Decision and transition option links in process or procedure diagrams have the following property dialog:



  The only additional information is the condition on the link.

2.2.2 Creating and opening components

Some diagrams may contain symbols that are defined via another diagram. E.g., block and system diagrams may contain process and block symbols that will be described via

process and block diagrams. These diagrams are displayed as children of the first diagram in the project tree in the main window (see “Project” on page 7).

The definition diagrams for symbols are not added to the project as described in the paragraph “Adding components to the system” on page 11, but as follows:

- Select the symbol for which you want to create the definition diagram;
- Select the item "Open definition..." in the contextual menu or the "References" menu or double-click on any part of the symbol, except its text (hint: the cursor should be an arrow, not a text caret);
- If the definition diagram for the selected symbol doesn’t exist, the project manager will pop up and ask if you want to create it. If you answer "OK", the "Add component" dialog described in “Adding components to the system” on page 11 will allow you to enter the features for the new node.
- The definition diagram will then appear in the current window if it’s reusable, or in another one if it’s not.

You may open definition diagrams for the following symbol types:

- Block and process symbols in block or system diagrams, including instances of block or process types;
- Block types and process types in block or system types diagrams;
- Process creation symbols in process or procedure diagrams;
- Procedure declarations and procedure call symbols;
- Composite state declarations or usage symbols;
- Service symbols in composite state diagrams;
- Declaration text boxes containing an "INHERITS" line in process types;
- MSC references in MSC and HMSC diagrams.

Automatic creation of definition diagrams is also supported for all these symbols, except the process creation symbol, where the created process may be anywhere in the system.

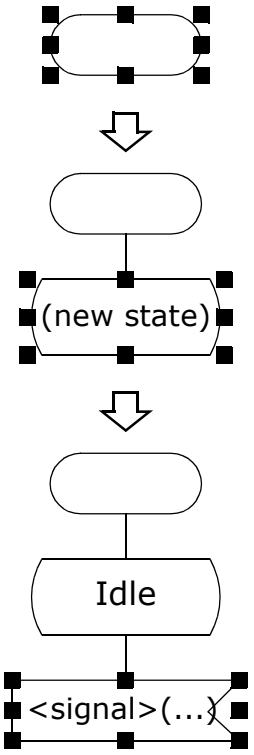
Please note:

- Renaming or deleting a symbol having a definition diagram will rename or delete the node in the project tree. The deletion will display a confirmation dialog, asking whether the diagram file should be deleted.
- The reverse is not true: deleting or renaming a node in the project manager will not update the corresponding diagram. For example, if the name for a process diagram node is changed in the project manager, trying to open this process from its parent diagram will fail and display the dialog asking if the process diagram must be created.

2.2.3 Automatic insertion

This feature allows to automatically create a symbol just below the current symbol with a link between the two. It is available in process, process type, procedure, macro and HMSC diagrams. It allows to easily create a vertical flow of symbols without having to create all symbols and links manually.

The automatic insertion is done by double-clicking on the symbol tool for the symbol you want to insert:



Manually inserted "Start" symbol
Make sure it is selected

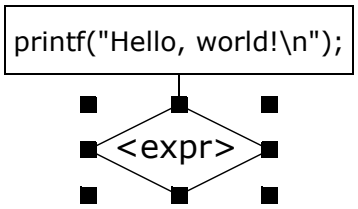
Double-click on "State" symbol;

"State" symbol automatically inserted
below current symbol.

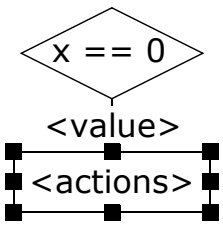
Double-click on "Signal input" symbol;

"Signal input" symbol is automatically inserted
below current symbol.

The automatic insertion will also choose automatically the "best" link type for linking the two symbols:

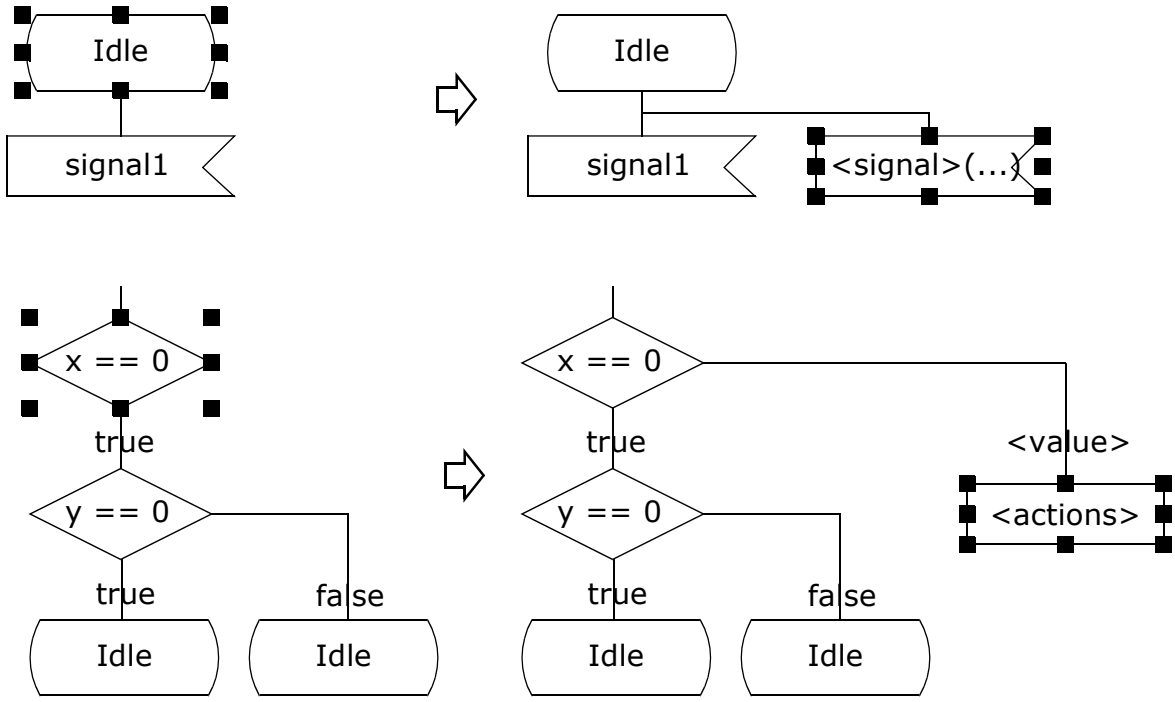


Automatic insertion of a condition after a task block

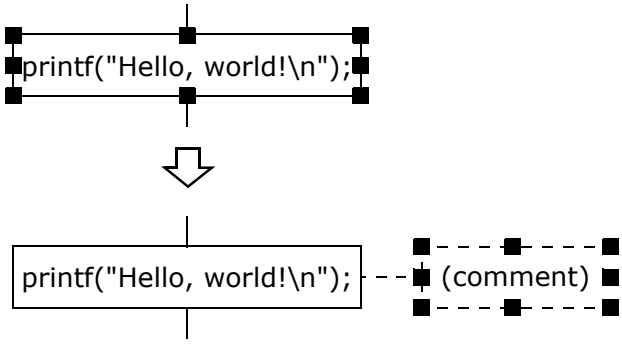


Automatic insertion of a task block after a condition

The position of the auto-inserted symbol is also computed to avoid symbol overlap:



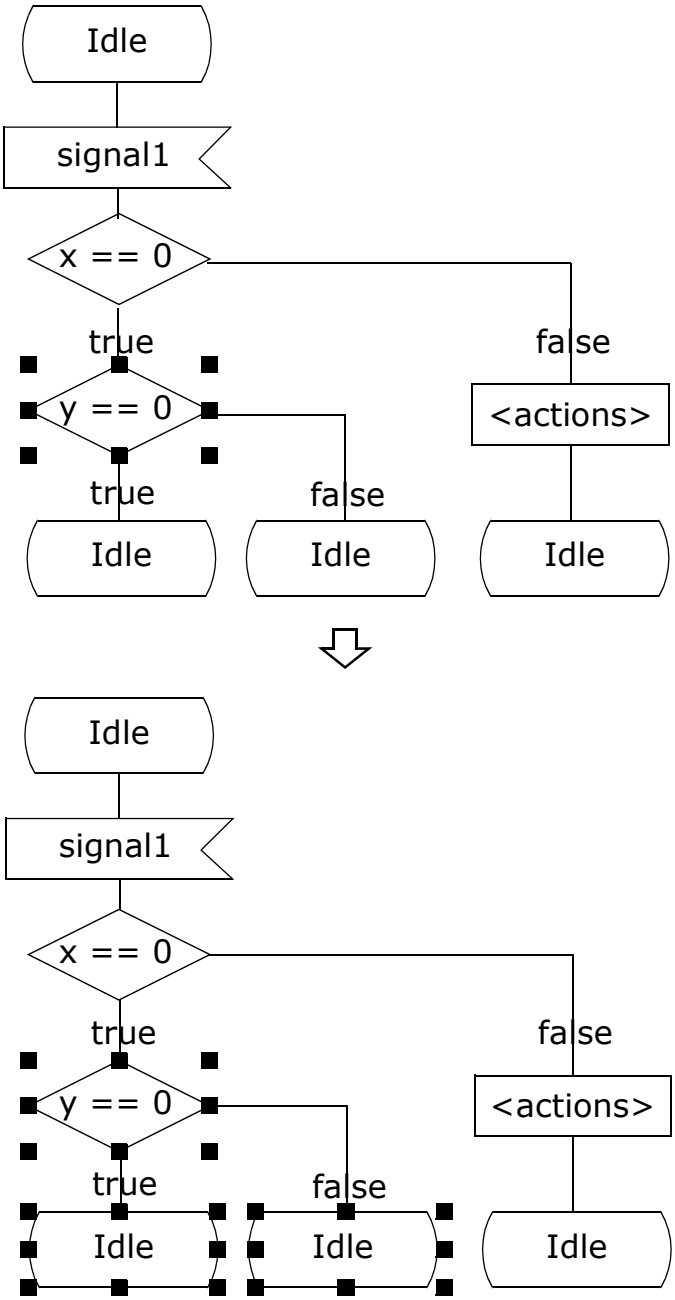
Auto-insertion is also provided for comment and text extension symbols. These symbols will be inserted at the right of the selected one:



2.2.4 Automatic transition selection

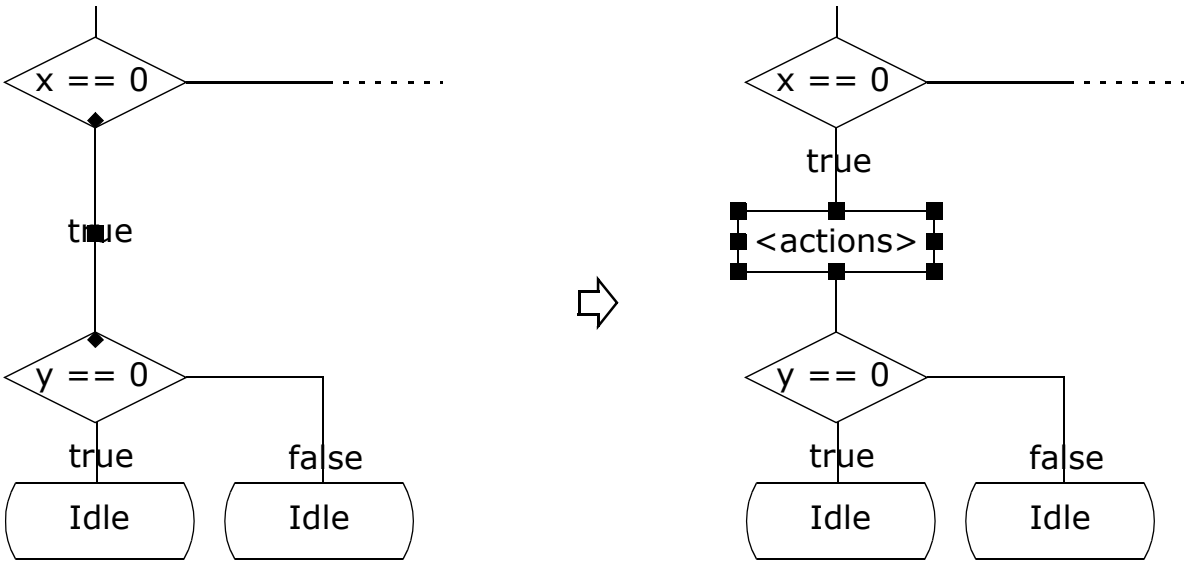
Sometimes, a symbol must be inserted in the middle of an existing transition. This case is not handled by the autoamtic insertion described above, as this feature won't move existing symbols. To ease such an insertion, RTDS allows to automatically select all symbols

following a given one in a transition. This is done via the "Edit" or contextual menus, item "Select to end":



This allows to move all symbols following a given one to make space for a new one inserted before it.

Once this is done, the new symbol can be inserted in the middle of an existing link by selecting the link and double-clicking on the symbol tool, as for auto-insertion below symbols:



2.2.5 "View" / "Go to" menu and state / message browser

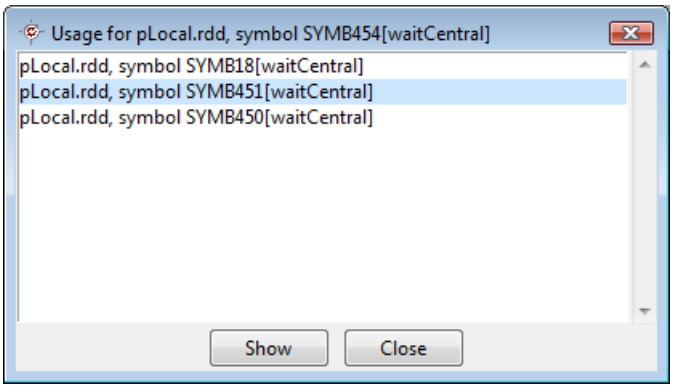
The process and process type editors include a feature allowing you to go directly to a given signal input in a given state. This feature is available:

- Via the "Go to" sub-menu in the "View" menu. This sub-menu includes one sub-menu per state defined in the process or process type. The sub-menu for a state includes an item for each signal input defined for this state. Selecting one of these items displays the corresponding symbol.
- Via the state / message browser that may appear in the right part of the editor window. This browser shows each state in the process, followed by each input message accepted in this state. Clicking on the message name displays the corresponding symbol in the diagram.

2.2.6 State and connector usage

The "View" / "Go to" menu and the state / message browser show the entry states and messages in transitions. RTDS also allows to find where a given state is used as a next state. This is also available for connectors: for a given "in" connector, it is possible to show where it is used as an "out" connector. This is done by selecting the state or "in"

connector symbol and selecting "Show usage..." in the "Edit" or contextual menu. The following window appears, showing all symbols using the given state or connector:



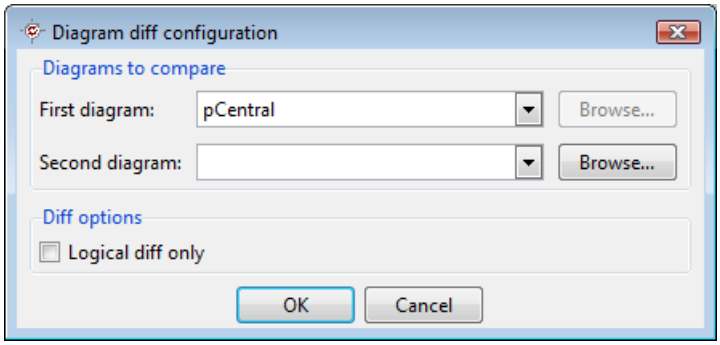
Each line continas a diagram file name, a symbol identifier and the text for this symbol. Double-clicking on a line (or selecting it and pressing the "Show" button) will open the given diagram and display the symbol.

Note that for process classes, the symbols using the state or connector in the super-class or all sub-classes are also displayed.

2.2.7 Diagram diff

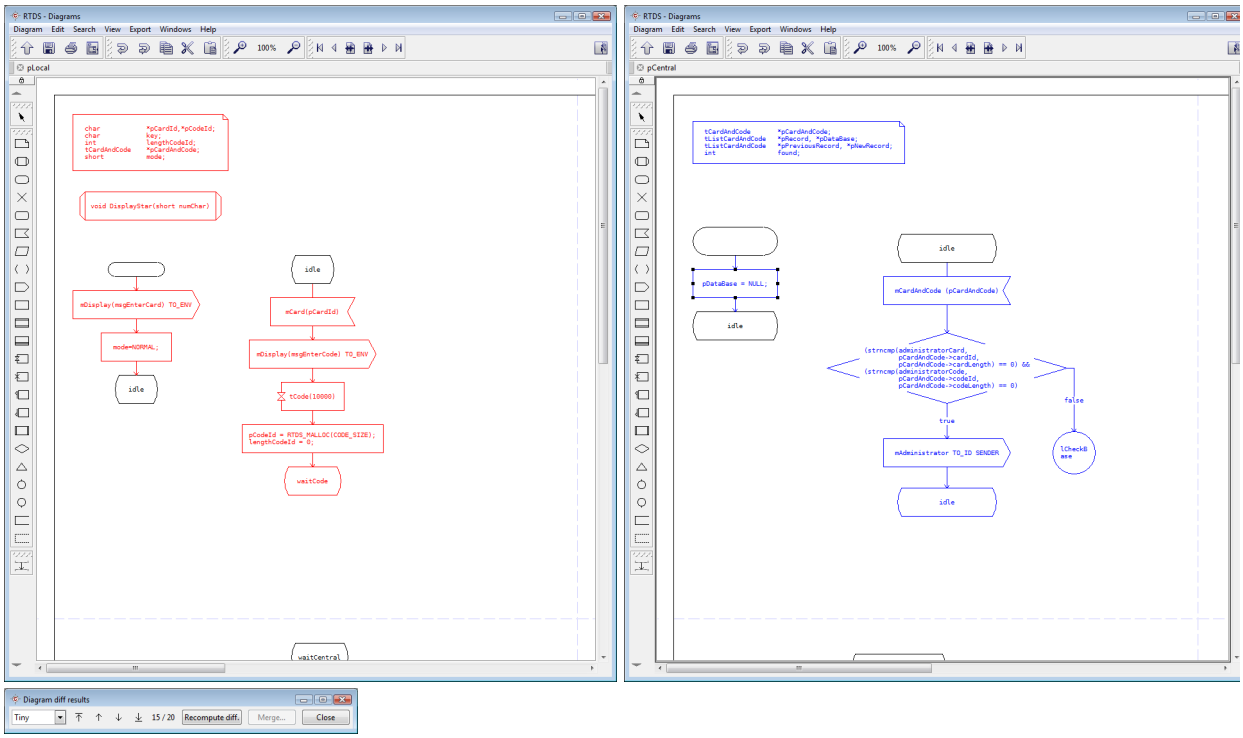
RTDS allows to make a graphical diff of two diagrams within a project, or of a diagram within the project with an external diagram. This feature is available in the diagram editor via the "*Make diff on diagram...*" item in the "*Diagram*" menu, or in the project manager in the "*Make diff on diagram...*" item in the "*Element*" menu.

The diff is configured via the following dialog:



The first diagram is always taken in the current project. The second diagram can either be chosen among the current project compatible diagrams in the drop-down menu, or read from an external file by using the "*Browse...*" button. If the "*Logical diff only*" option is checked, only logical differences between the two diagrams will be reported. If this option is not checked, differences may be reported for elements that appear in both diagrams if the symbol defining them have moved or has been resized.

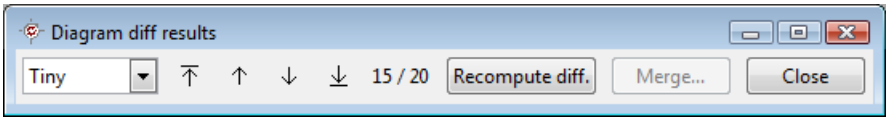
The results for the diff is displayed as follows:



Both compared diagrams are opened and automatically placed side by side on the screen. The different parts are identified by colors in the editors (NB: the colors set for symbols are ignored when in diff mode).

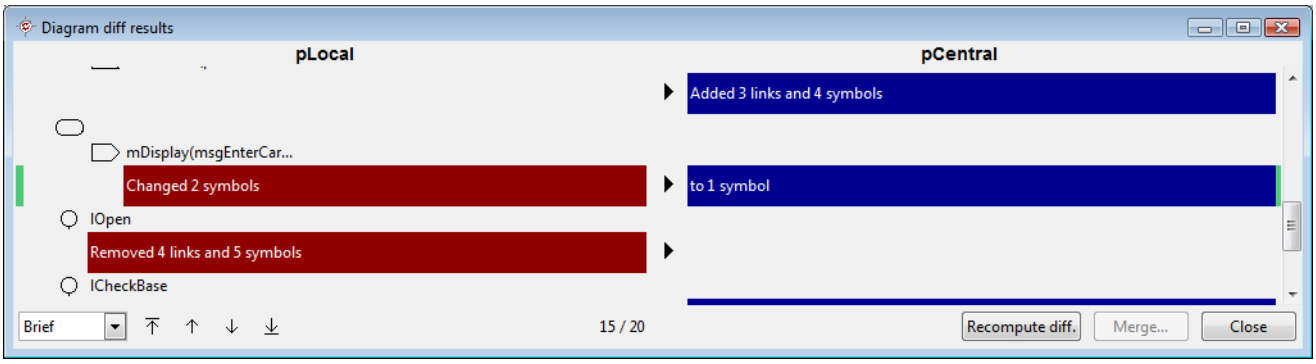
The window below the editors allow to navigate through the differences. This window has 3 possibles layouts:

- The "Tiny" layout is the one shown above:



The only thing it allows is to navigate through the differences and to recompute the diff (see below).

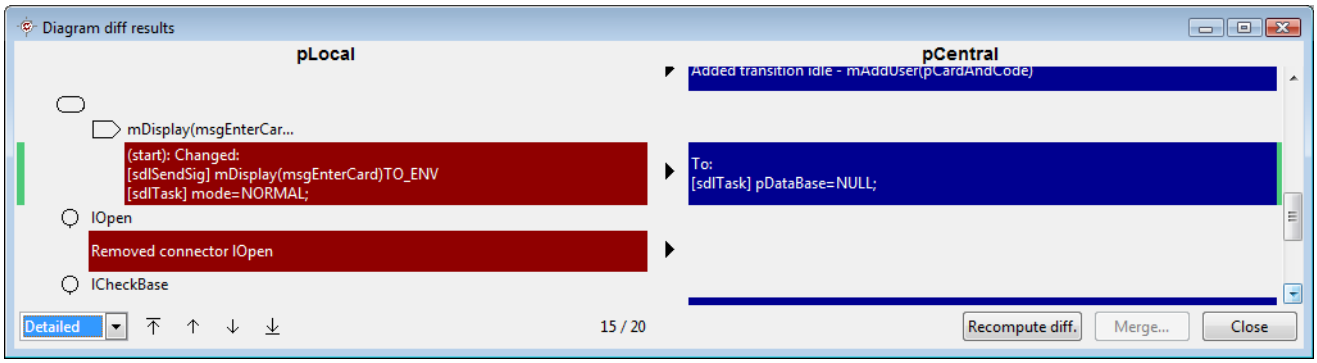
- The "Brief" layout is as follows:



The differences are grouped by transition. For each difference, only the number of impatced elements is displayed. When navigating through differences, the currently displayed one is identified by the green borders on each side. Clicking

on a difference will make it current and display the corresponding elements in the diagrams.

- The "Detailed" layout is as follows:



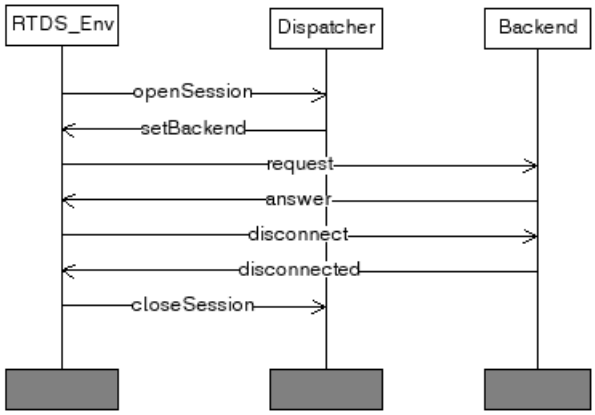
The differences are grouped and shown as in the "Brief" layout, but a full description is given for each difference.

If one of the diagrams is modified while showing differences, the differences can be recomputed using the "Recompute diff." button.

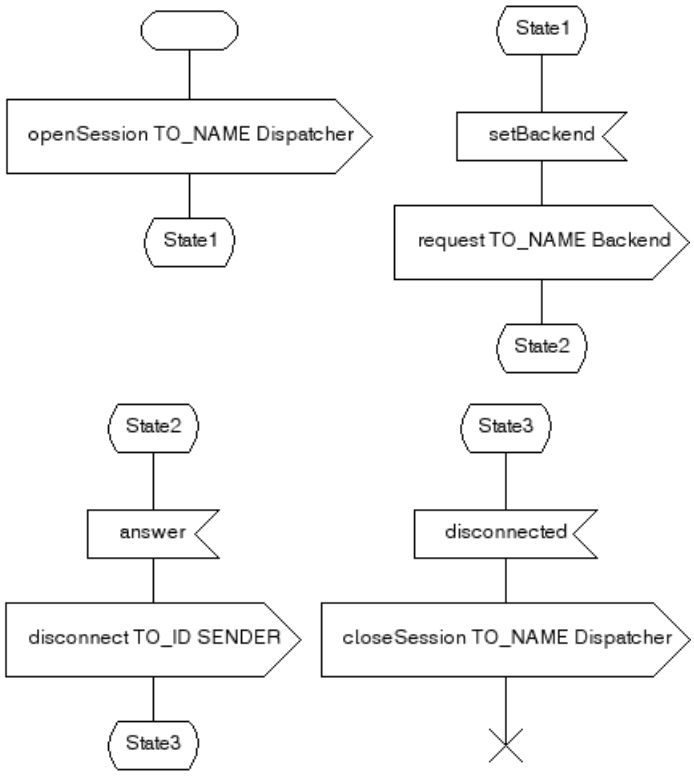
2.2.8 Automatic environment process creation

This feature is only available in system, block and block class diagrams. It allows the automatic creation of an environment process from a MSC or a HMSC diagram.

The new process's state automaton is extracted from the sequence of sent and received messages for a given lifeline in a MSC or the set of MSCs referenced by a HMSC. For example, the following MSC:

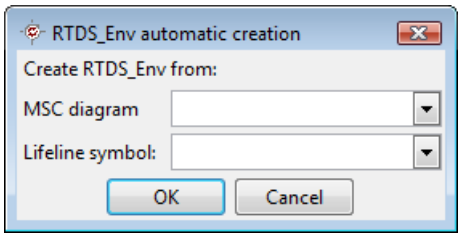


will generate the following state automaton:

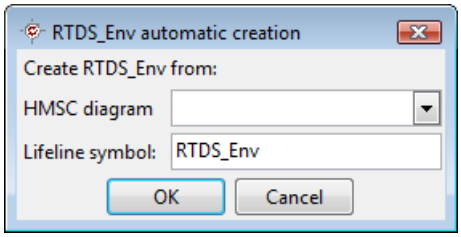


This function is called as follows:

- In the block or system diagram, select the item "*Create RTDS_Env from*" / "*MSC...*" or "*HMSC...*". One of the following dialogs appear:
  - For a creation from a MSC:



  - For a creation from a HMSC:

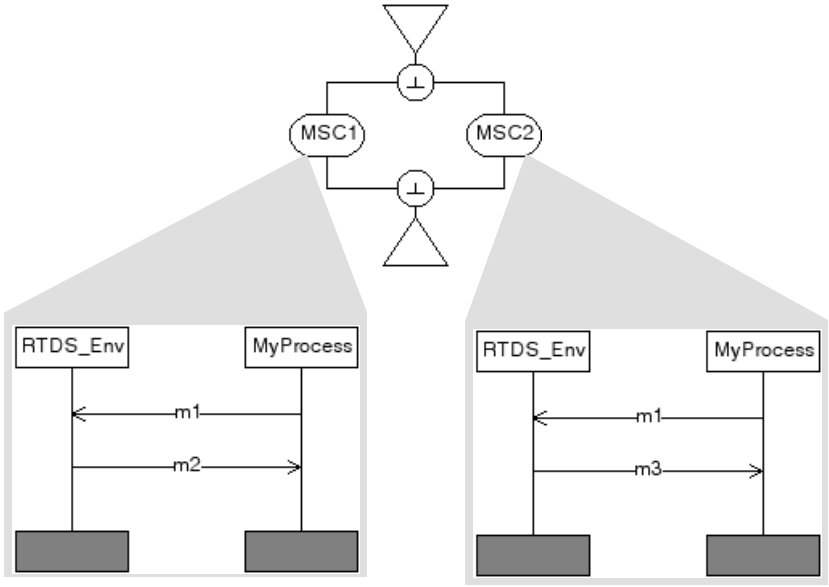


- Select the source diagram and select or type the name of the source lifeline in the dialog, then press OK. The cursor turns into a regular symbol insertion icon.
- Click on the desired location for the new environment process.
- The new process symbol with the name "`RTDS_Env`" is then inserted with the corresponding channels and the process appears in the project tree.

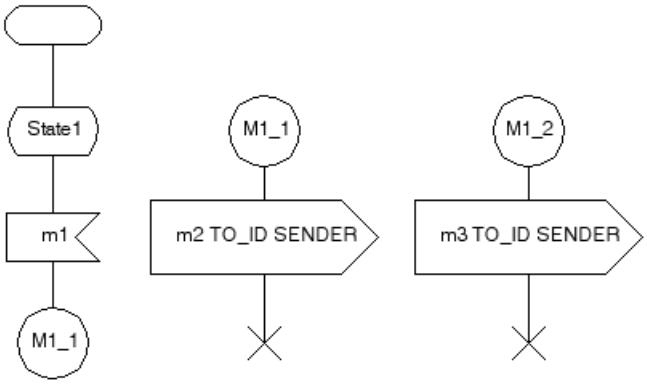
Notes:

- This feature is only available for SDL-RT diagrams.

- When creating from a HSMC diagram, the source diagram cannot contain parallel sequences, or the creation will fail. Alternatives are allowed.
- When creating from a HSMC, the behavior of the created process may be ambiguous. For example, the source HMSC with the MSCs it references may look like follows:



In this case, there's no way to know if the created process should send `m2` or `m3` after receiving `m1`. So the created process will look like follows:



Both options have been made available through two connectors. The default behavior is to send `m2`, but you can change it by changing the name for the connector after the message input symbol.
If several ambiguities are found, several connectors are generated. The name for the connector is always "`Mx_y`", where *x* identifies the ambiguity and *y* identifies one of the possible choices. So an "out" connector "`Mx_y`" may be connected to any "in" connector with the same *x*.

2.3 - MSC editor

The MSC editor is mainly the same as the editor for other SDL diagrams. However, there is a few extra features that are described in the following paragraphs.

2.3.1 Specific tools

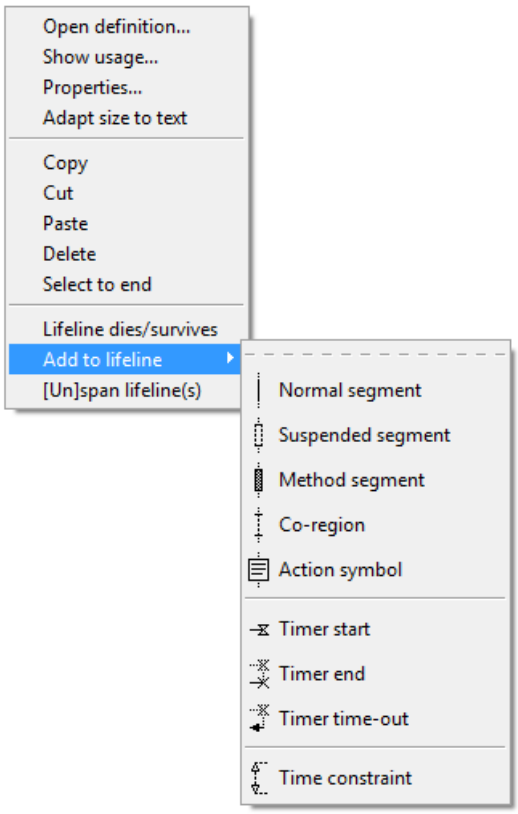
The top tool bar for MSC diagrams has two more MSC specific tools:

- allows to select a time range within the diagram: all events occurring to all lifelines between a given start time and a given end time may be selected, copied, cut and/or pasted somewhere else in the diagram. While this tool is selected, horizontal guidelines follow the mouse cursor to indicate precisely what will be selected.
  To select a time range, press the mouse button at the desired start time and drag to the desired end time.
  Once a time range has been copied or cut, pasting is done by clicking at the desired insertion time. The paste operation also displays a horizontal guideline, and may be cancelled by hitting the "Esc" key or by selecting the regular selection tool.
  Please note that it's impossible to select a time range in a diagram and to paste it in another.
- allows to insert empty space in the diagram: press the mouse button at the desired insertion position and drag. When releasing the button, and if it's possible, a space having the length between the start and end position will be inserted in the diagram.

2.3.2 Manipulating components in lifelines

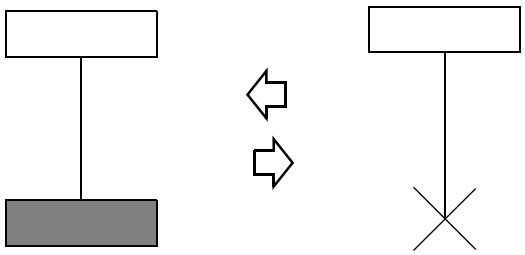
To the difference of all other symbols, lifeline are composite symbols: they may include several components like segments, timers or time constraints. They may also die before

the end of the diagram or survive it. All these features are managed via the contextual menu in the MSC editor:



When a lifeline is selected, the items in this menu have the following action:

- "Lifeline dies/survives": toggles the instance tail / instance stop ending for the lifeline:



- "Add to lifeline": adds to the lifeline a segment, an action symbol, a timer or a time constraint. After selecting an item in the sub-menu, press the mouse button at the desired start position of the segment, action symbol, timer or time constraint in the lifeline, and drag to its end position (if applicable). To cancel the insertion, hit the "Esc" key or select the selection tool.
- "[Un]span lifeline(s)" attaches or detaches a spanning symbol from a set of lifelines. Spanning symbols are conditions or MSC references, which are attached to one or several lifelines: if the lifelines are moved, the size of the symbol is updated so that the lifelines are always spanned by the symbol.
  This menu item only works when a spanning symbol and one or several lifelines are selected:
  - If the selected lifelines are not spanned by the symbol, they're added to the set of spanned lifelines;

- If the selected lifelines are already spanned by the symbol, they're removed from the set of spanned lifelines.

A dialog will inform you about the performed operation.

Please note: there is no visual information on the diagram about lifelines spanned by symbols. The lifelines are always behind spanning symbols, even if they're not spanned.

The "Delete" menu item also has a special meaning if a lifeline item such as a component, timer or time constraint is selected. In this case, only the item is deleted, not the entire lifeline. A confirmation dialog will always specify what is deleted. Note that it is impossible to copy or cut a single item. To remind you of this, when a lifeline item is selected, the whole lifeline will still appear as selected, but with white handles instead of black ones.

2.3.3 Message parameters display

A specific sub-menu in the "View" menu controls the message parameter visibility:

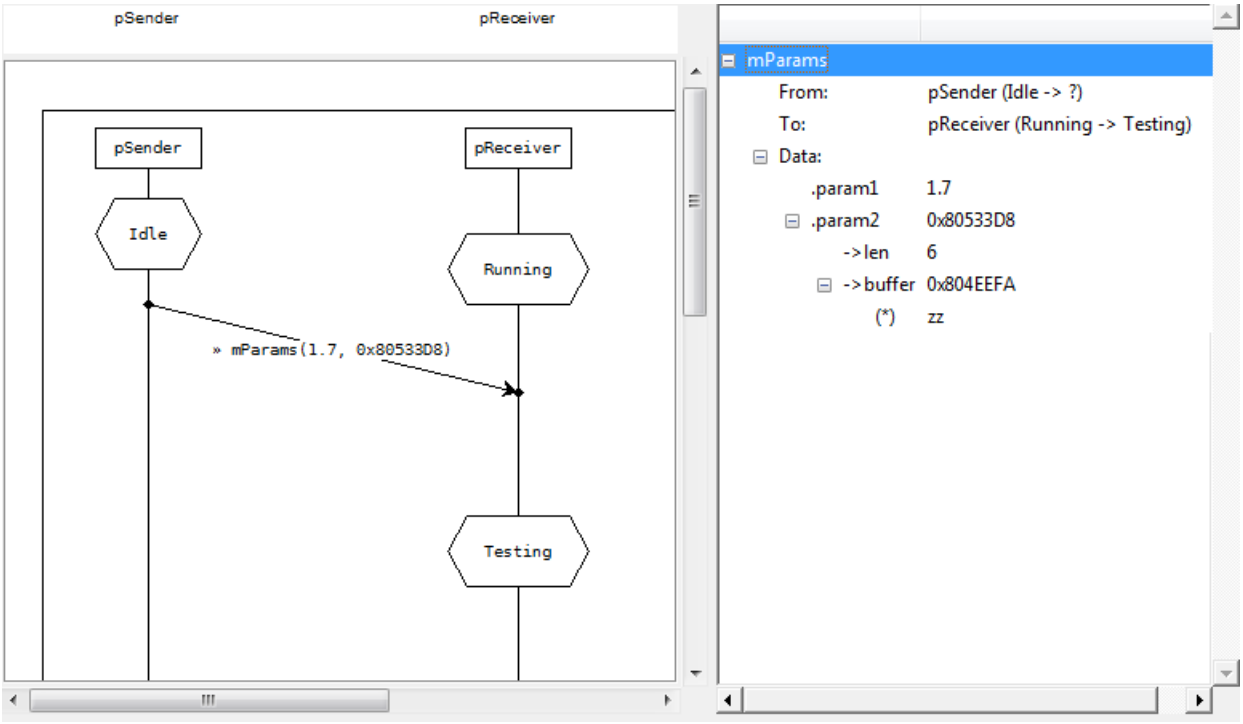
- A visibility set to "Full" displays the full text for the message parameters as it is recorded in the diagram file. The parameters for structured messages are then displayed in the format described in paragraph "Sending SDL messages to the running system" on page 209. This can make the diagram quite difficult to read, as this format is quite complex;
- A visibility set to "Abbreviated" still displays completely parameters for non-structured messages, but only displays the first level of parameter values in structured parameters. An example of this visibility can be seen below;
- A visibility set to "None" hides all message parameters.

This visibility setting is stored with the diagram. Please note it is only possible to modify the text for the message parameters if the visibility is set to Full.

When the visibility is set to "None" or "Abbreviated", structured messages are indicated by a "»" before their name. Their parameters may be displayed by clicking on the message link: a panel then appears in the right part of the editor window displaying the parameters as a tree. For example, for a message with the full text:

```
mParams(|{param1|=1.7|,param2|=0x80533D8|:|{len|=6|,buffer|=
0x804EEFA|:zz|}|})
```

the display with parameter visibility set to "Abbreviated" and the link selected is:



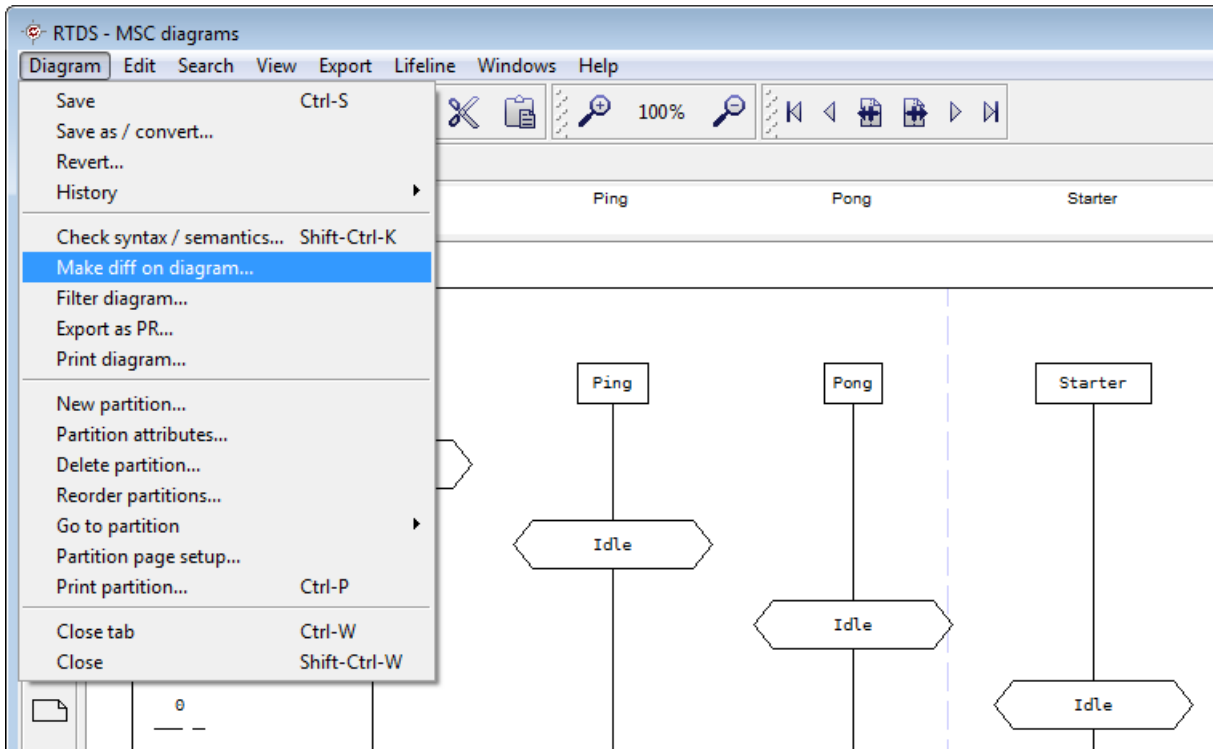
Other information is also displayed in the panel, such as the sener and receiver process and their states before and after they sent / received the message.

2.3.4 MSC Diff

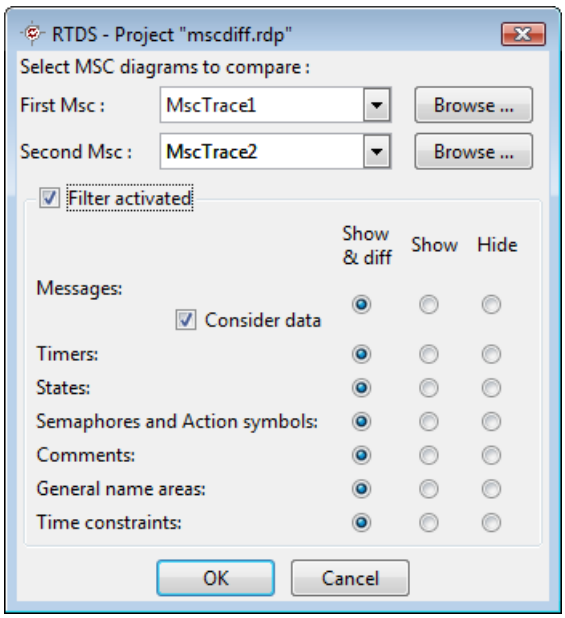
This command allows to show the differences between two MSC diagrams.

2.3.4.1 Running the diff

It can be launched from the MSC editor's "Diagram" menu, or from the project manager's contextual menu or "Element" menu when an MSC diagram is selected.



A dialog window pops up:



Here can be selected the two MSC diagrams from the current project or from the file system. Filters can also be applied on the result of the MSC diff. Symbol types can be:

- Removed from the resulting diagram ("Hide"), or
- Viewed but not checked in the diff ("Show"), or
- Viewed and checked in the diff ("Show & diff").
  In this case a symbol appearing only in one of the two diagrams will be displayed with a specific color.

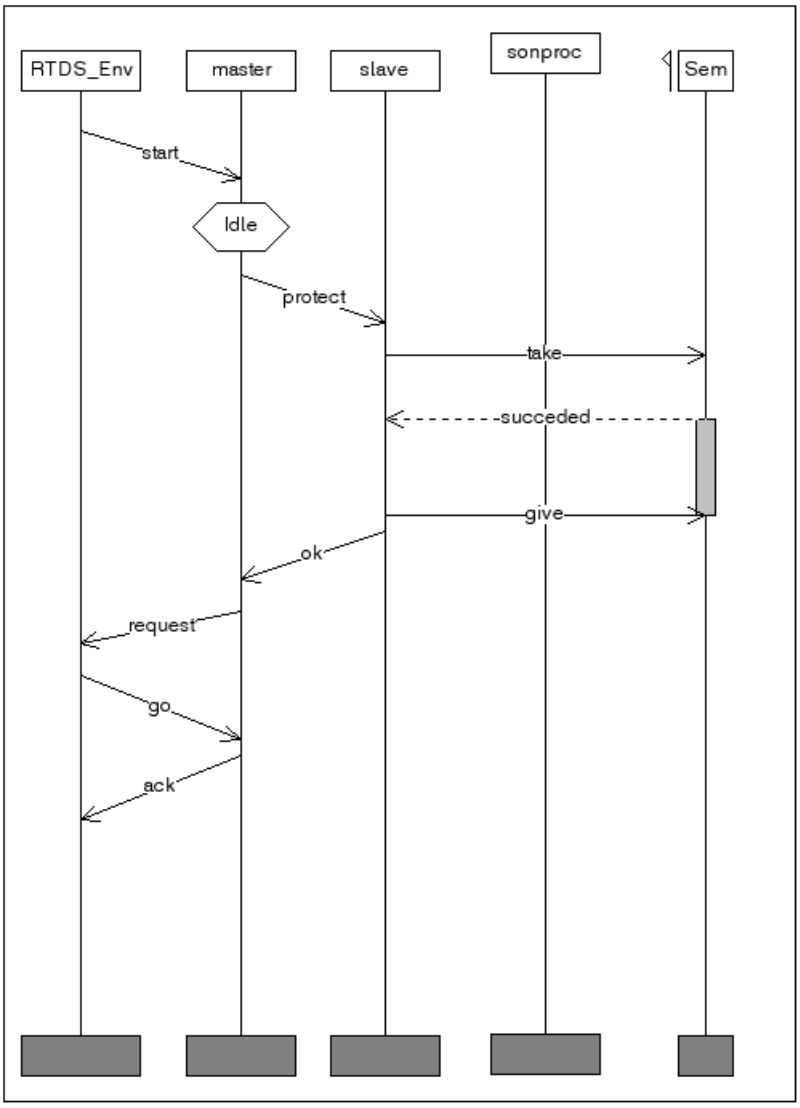
2.3.4.2 Result analysis

The resulting MSC identifies the lifelines (processes) between the two diagrams by their name and if necessary (if there are several processes with the same name), by the sequence of their events. If two lifelines in the two diagrams represent the same process but do not have the same name, they will not match.

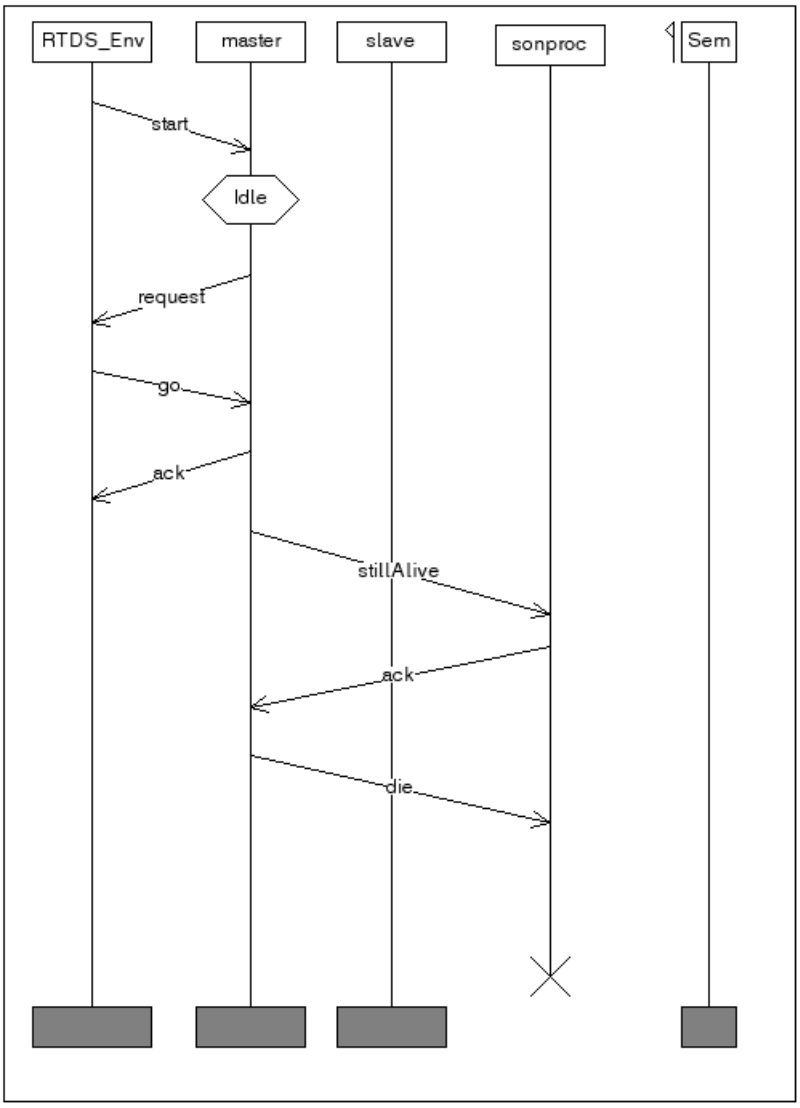
Note the MSC diff searches for the difference in the sequence of events on the lifelines. The elapsed time between two events on the resulting diagram is not significant.

2.3.4.3 Example

The diff is made on the following two MSC diagrams:



First MSC diagram in diff

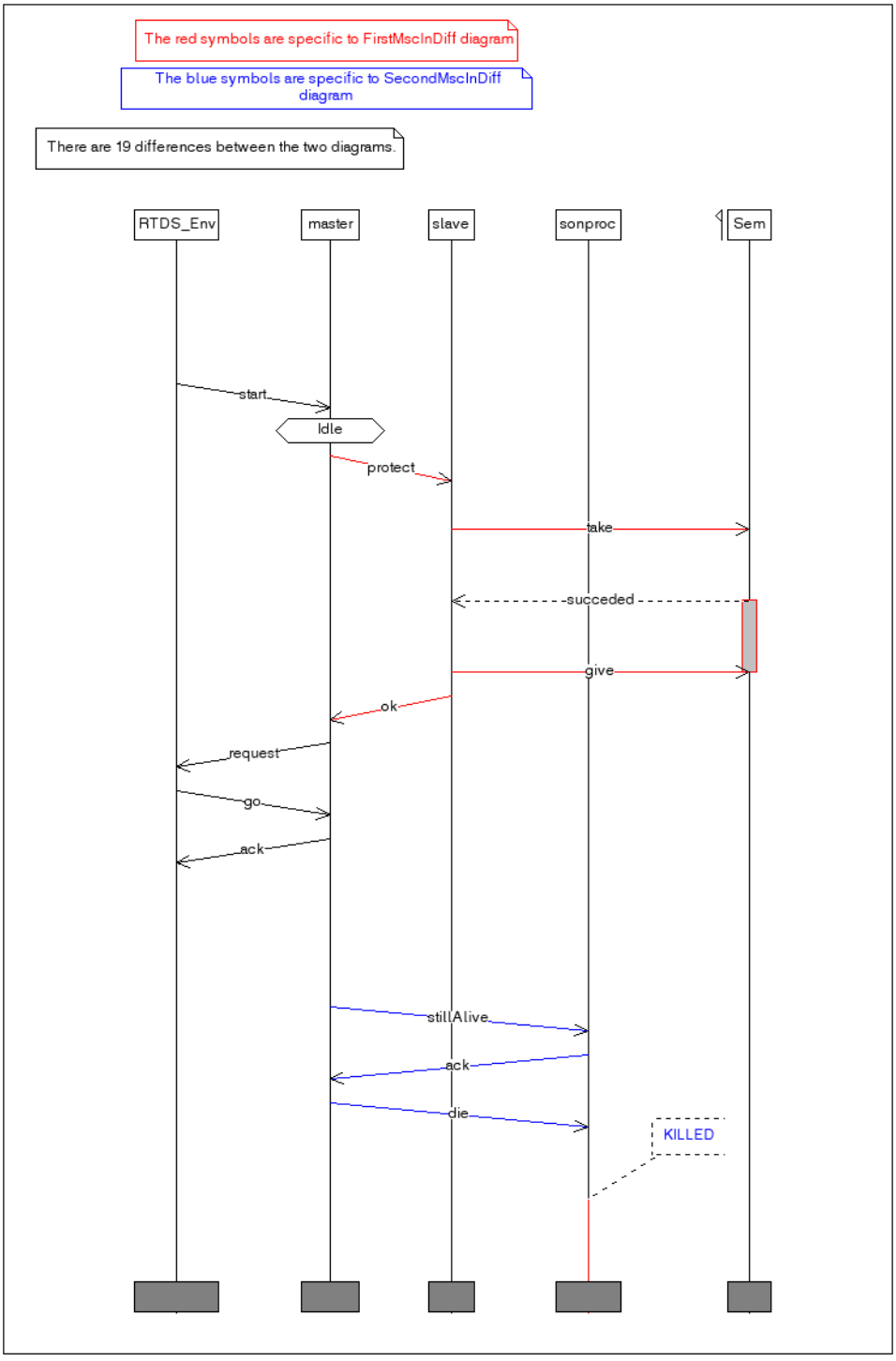


Second MSC diagram in diff

The differences are quite clear:

- The "slave" process takes the semaphore "Sem" in the first diagram, but not in the second.
- The processes "master" and "sonproc" exchange messages "stillAlive", "ack" and "die" in the second diagram, but not in the first.
- Process "sonproc" dies in the second diagram, but not in the first.

Here is the result of the diff:

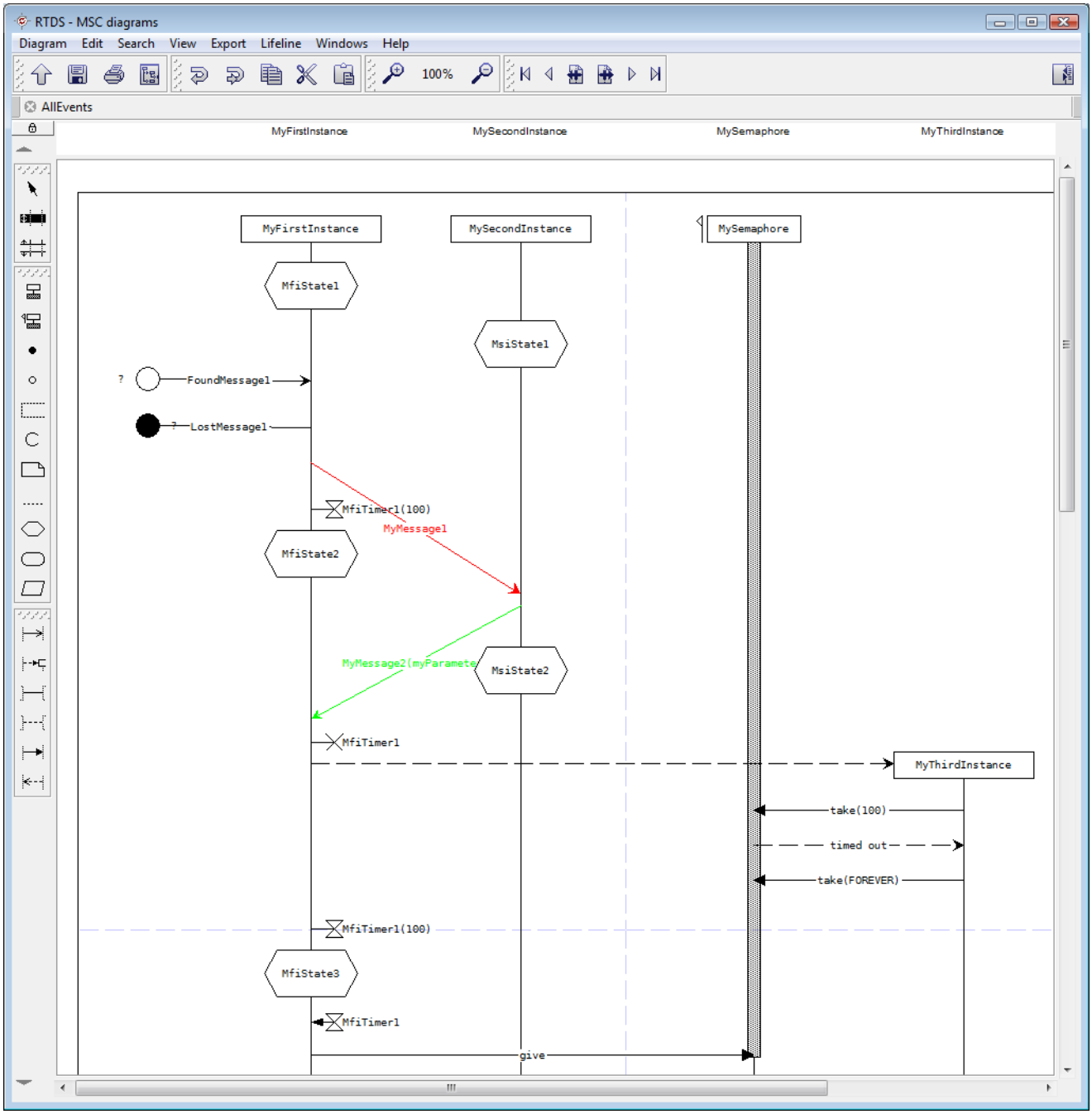


The differences are identified by colors: in the diff diagram, the events specific to the first diagram are represented in red, and the events specific to the second diagram are represented in blue.

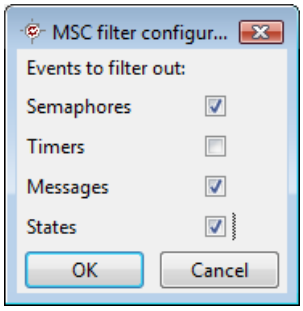
2.3.5 Filtering

Large MSCs might get very difficult to read; in that case the MSC filtering feature can be used to remove useless information from the diagram.

In the MSC diagram editor go to the *Diagram / Filter Diagram...* menu:

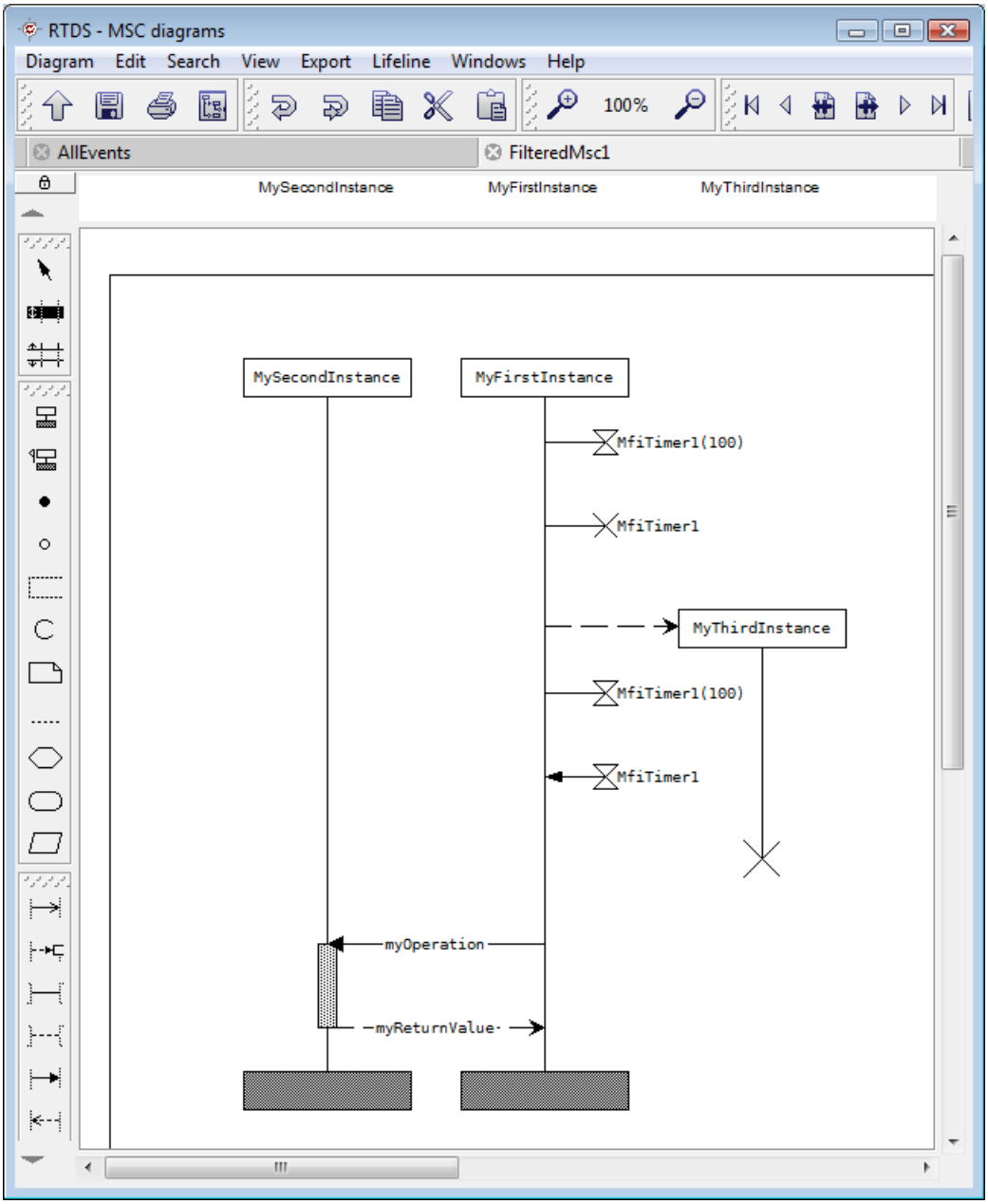


The *MSC filter configuration* window pops up:



Select the information to be filtered out of the MSC and click OK.

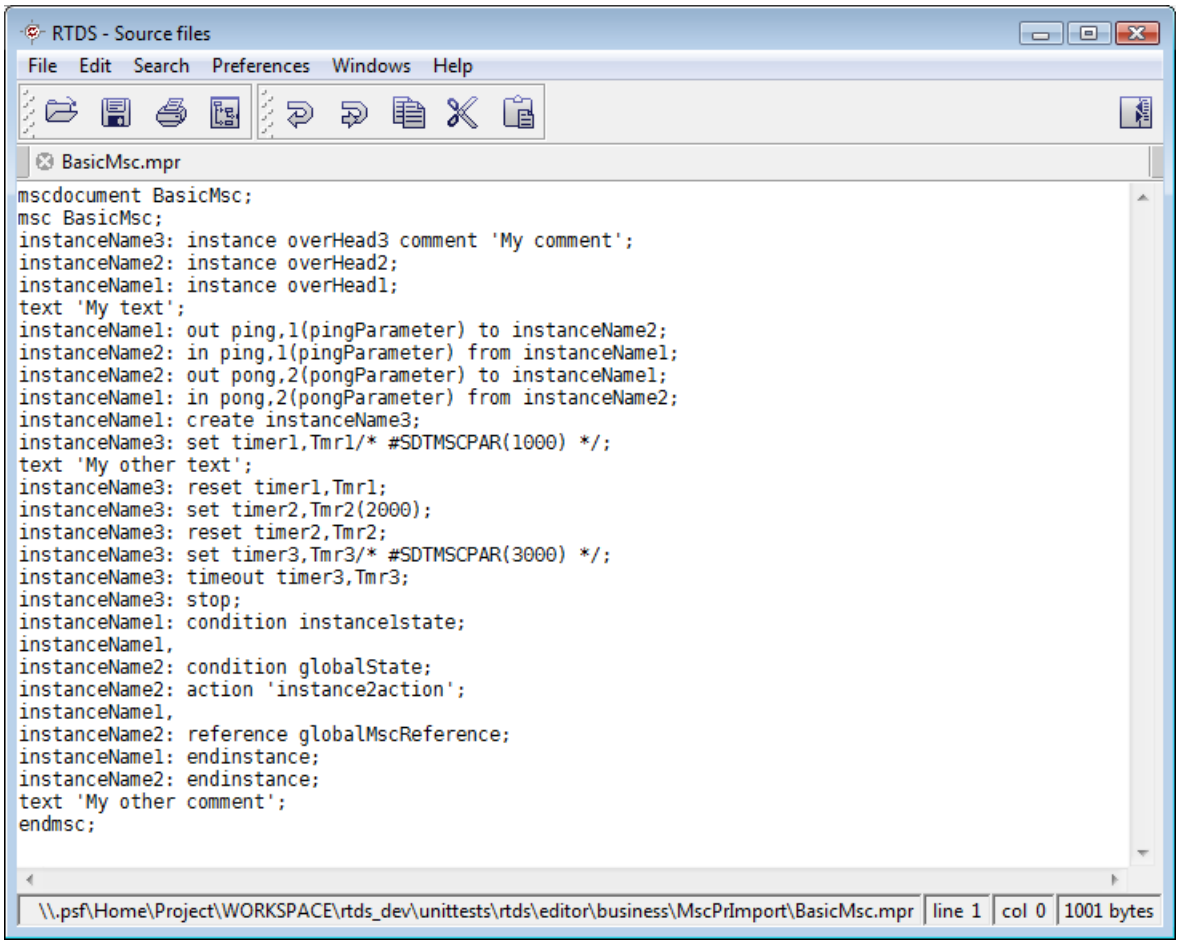
A new MSC is created with the selected elements filtered out:



Please note the resulting MSC might not have the same layout as the original MSC. This is because the original MSC is translated to a list of a MSC events that is filtered. The resulting MSC is built out of the sequence of left events. So for example the vertical space between events is always the same.

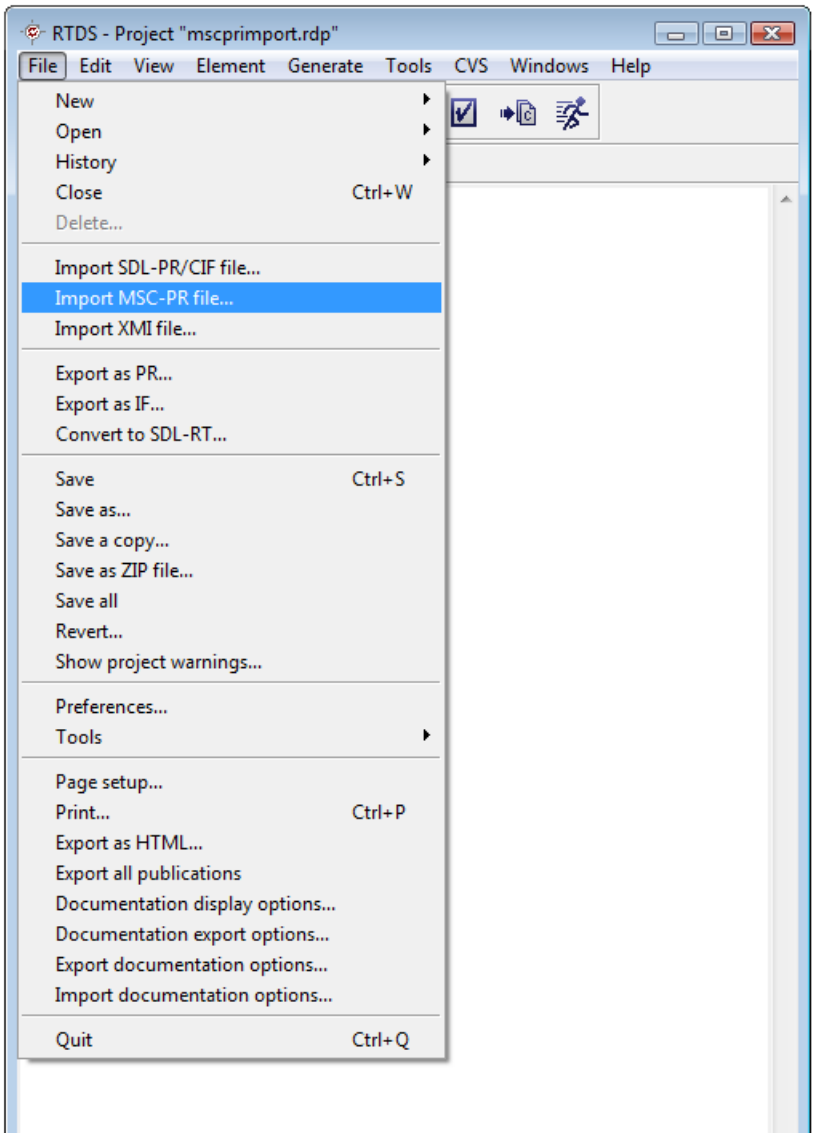
2.3.6 MSC PR import

It is possible to import MSCs stored in PR (Phrasal Representation) textual format as defined in ITU-T Z.120 recommandation. The MSC must be event oriented (as opposed to instance oriented) and the CIF information if any will be ignored.



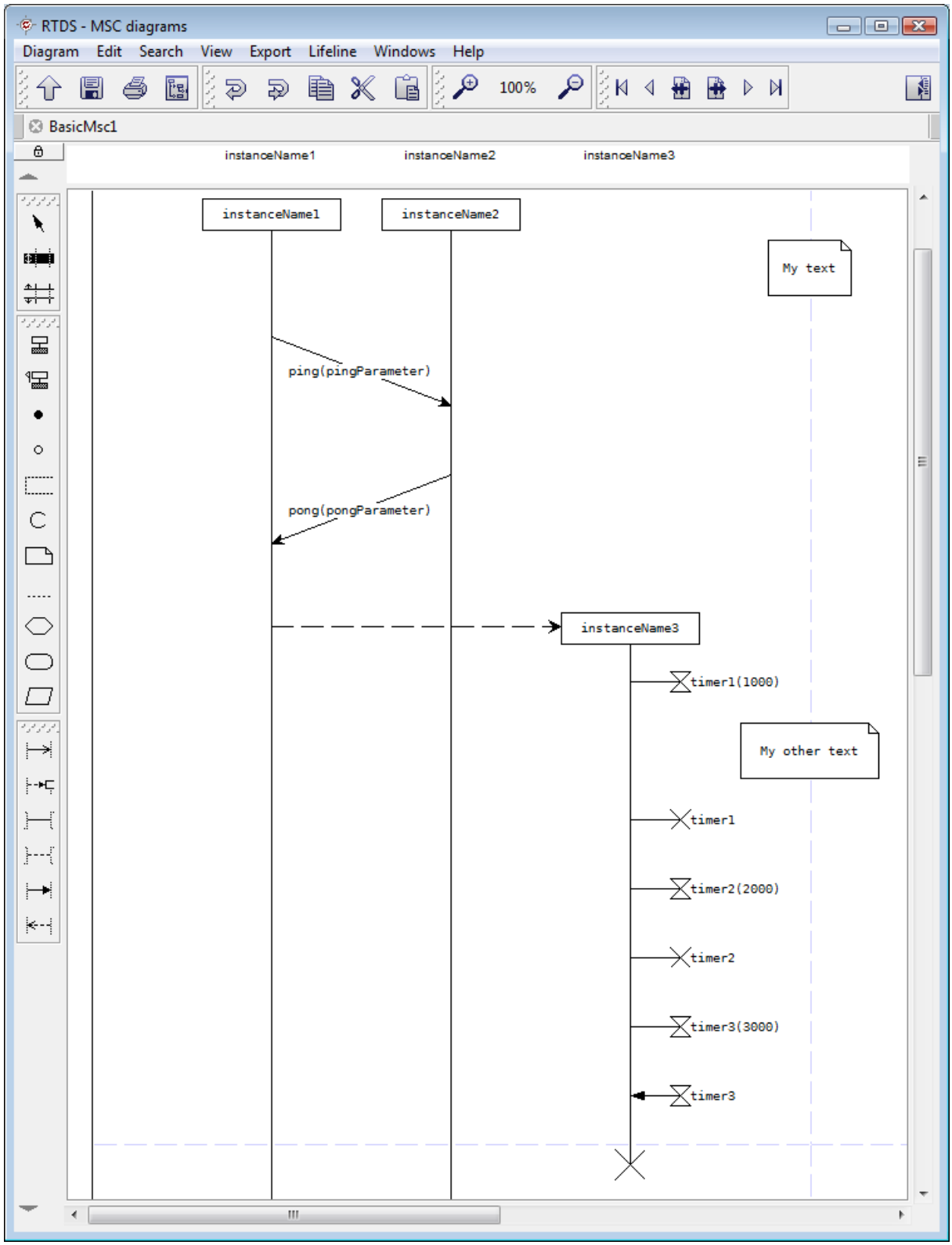
A Z.120 MSC PR example

In the Project Manager, go to the File / Import MSC-PR file... menu and select the file to import.



Import MSC menu

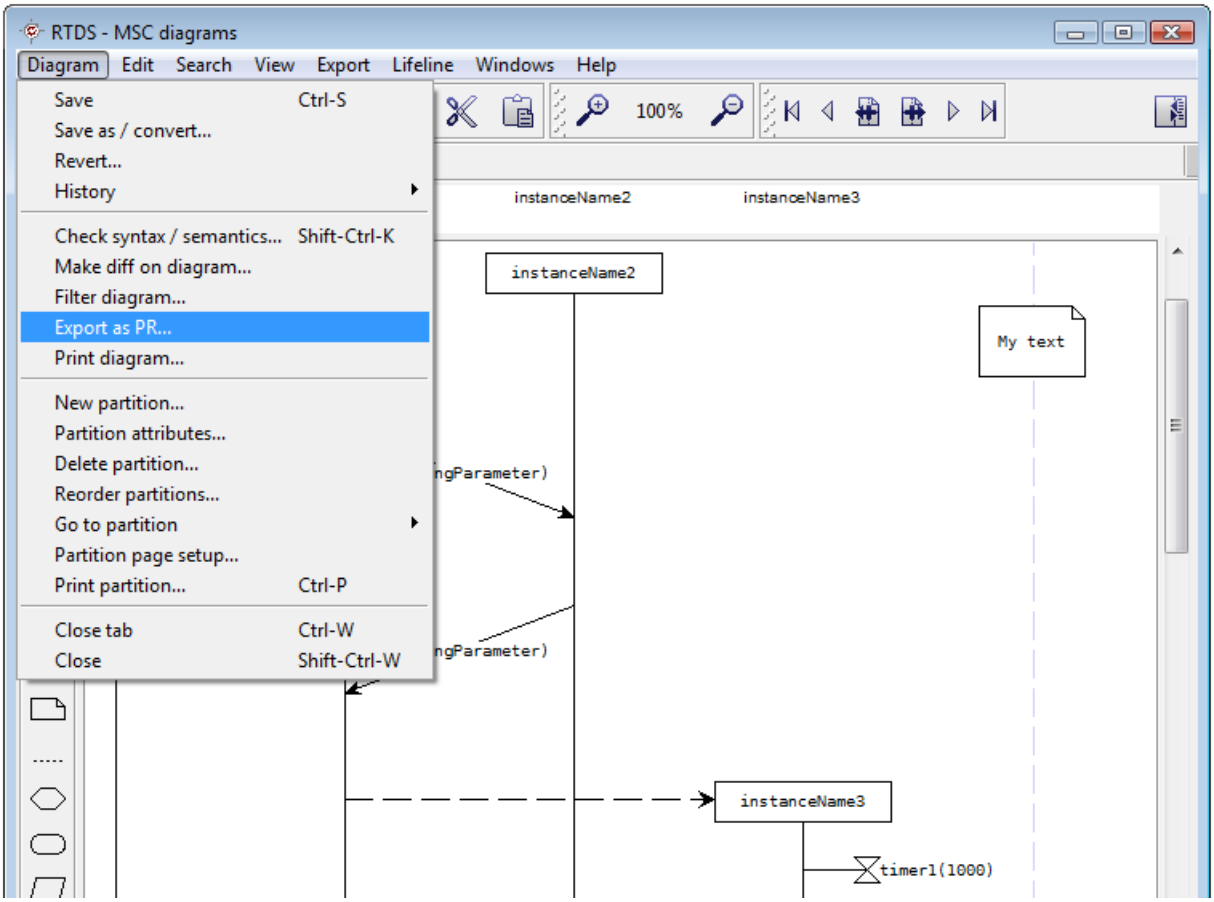
The resulting MSC will be added to the project.



Imported MSC

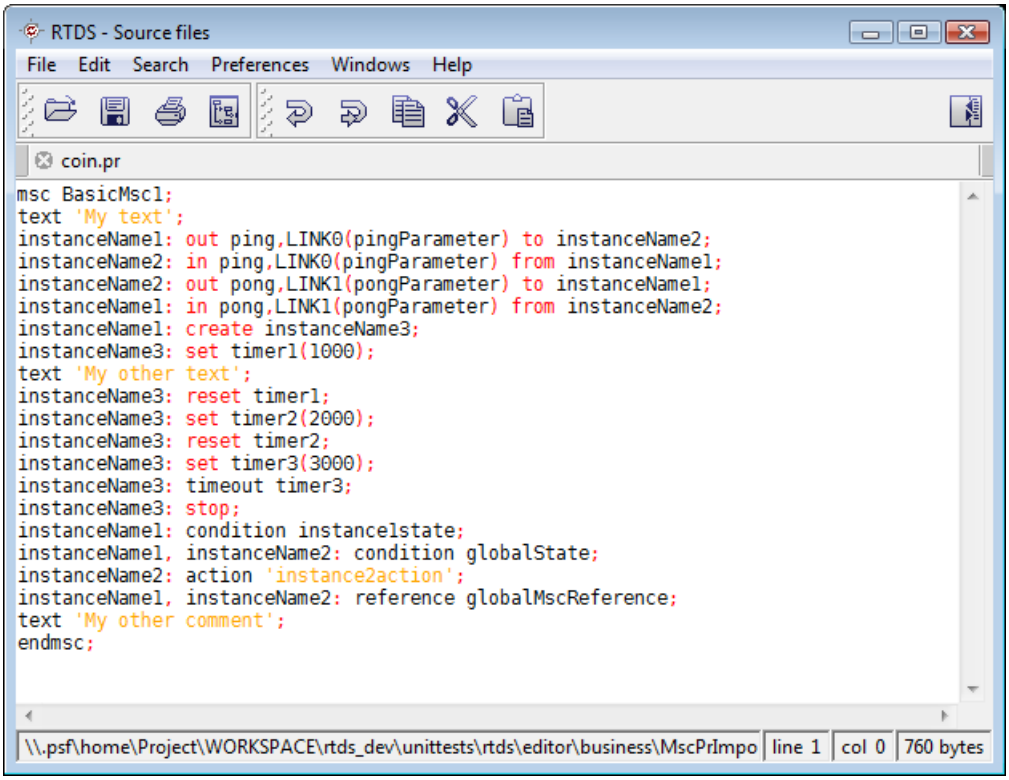
2.3.7 MSC PR export

It is possible to export MSCs to an event oriented Z.120 MSC PR file. In the MSC diagram to export, go to the *Diagram / Export as PR...* menu.



Export as PR menu

The results of the export is as follows:

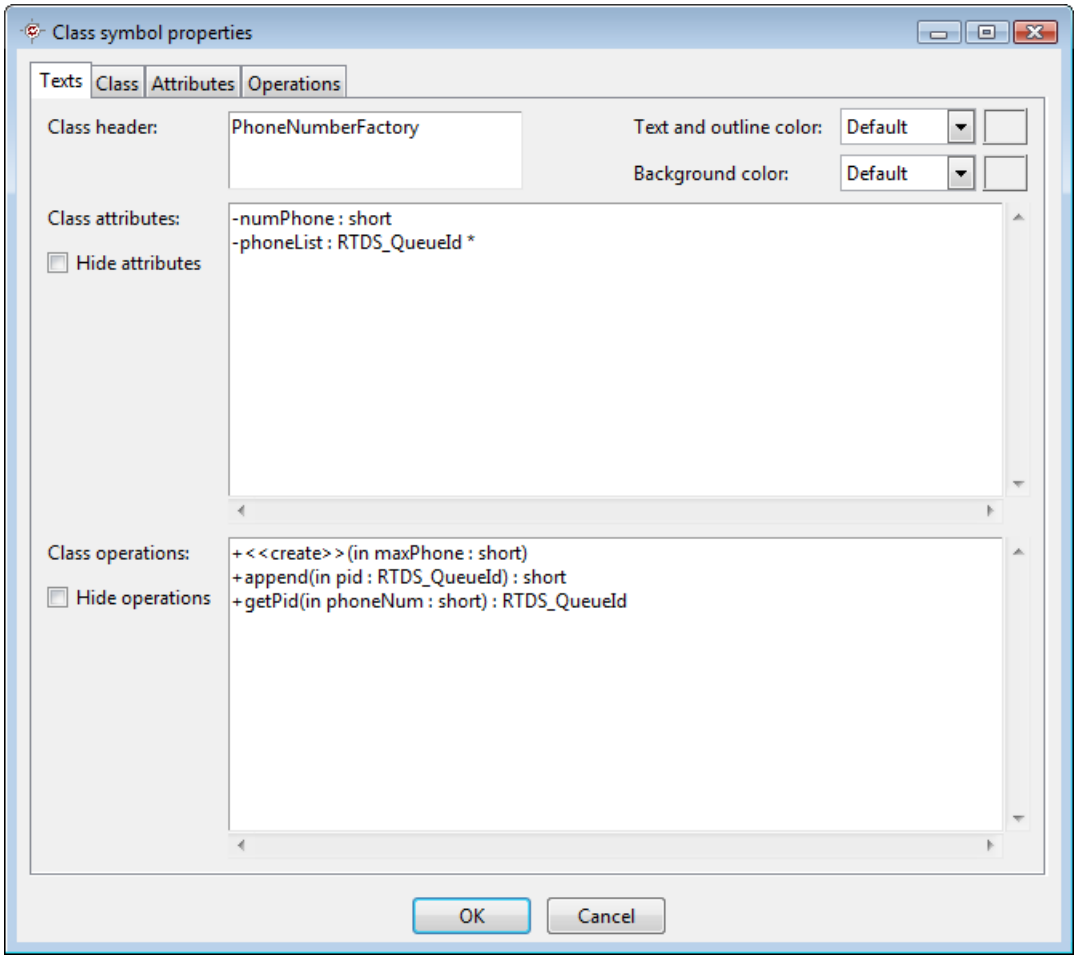


Export MSC PR example

2.4 - UML diagrams

2.4.1 Symbol properties

For symbols that may show attributes and/or operations (class symbols in class diagrams, nodes and components in deployment diagram), a specific property sheet is available:



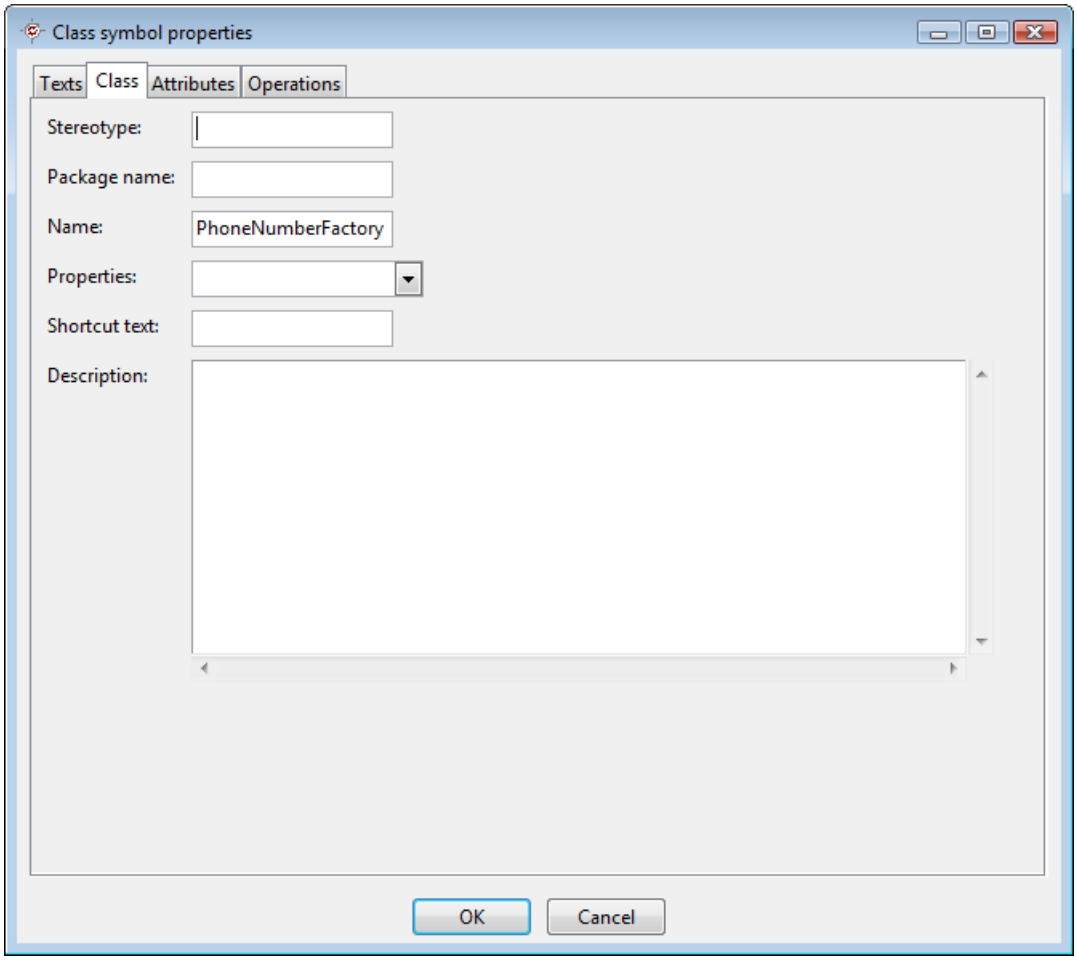
This property sheet is divided into 3 or 4 tabs depending on the selected symbol. These tabs are described in the following paragraphs.

2.4.1.1 "Text" tab

This tab is shown above. It contains the standard symbol colors and the textual representations for all texts associated to the selected symbol: class header, attributes and operations. The operations do not appear for nodes or components since they are meaningless for these symbols. Two check-boxes are also available, allowing to hide the attribute and operation parts in the displayed symbol respectively.

2.4.1.2 "Class" tab

This tab is the second one in the dialog:

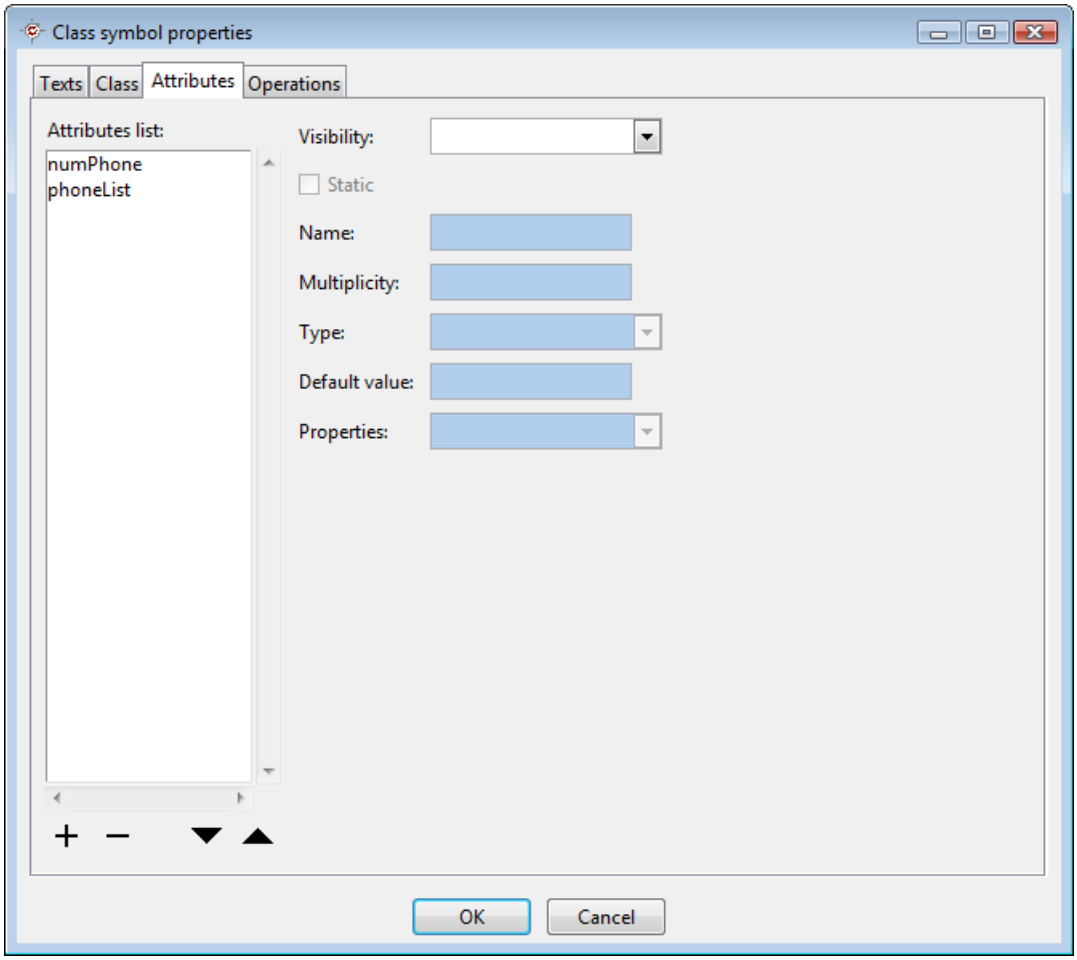


It contains the class's stereotype, package name, name, property string and description. These will be included in the class header as:

`<<stereotype>> package-name::class-name {property-string}`

2.4.1.3 "Attributes" tab

This tab is the third in the dialog:



The list in the left part allows to manage the attributes. Attributes may be created ("+" button), deleted ("-" button) or re-ordered (arrow buttons).

The fields in the right part allows to modify the attribute selected in the list. The text for the attribute will be:

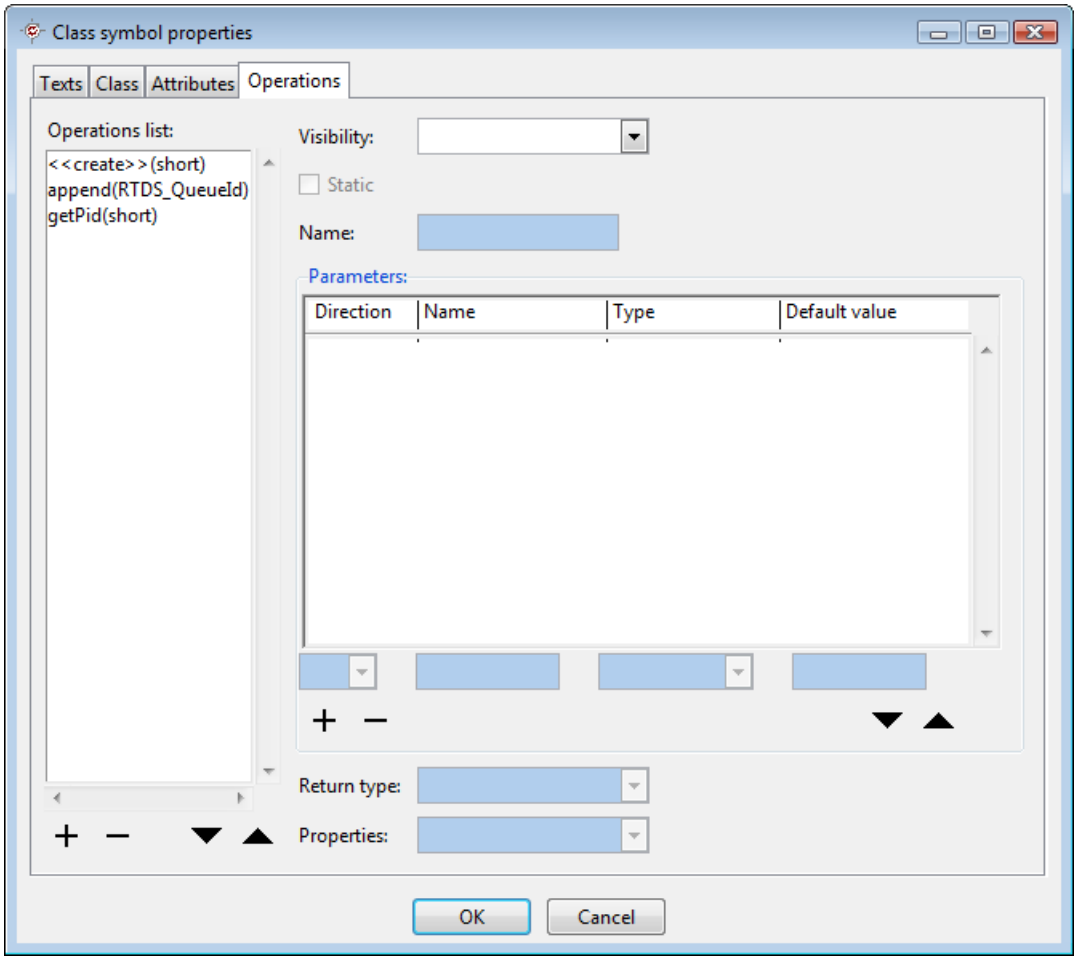
visibility name[*multiplicity*] : *type* = *default-value* {*property-string*}

The visibility is rendered as the standard UML character ('+' for public, '#' for protected and '-' for private). The multiplicity, type, default value and property string are included only if they are not empty.

Any modified attribute will be automatically updated in the attributes text in the "Text" tab.

2.4.1.4 "Operations" tab

This tab is the fourth in the dialog:



This tab is not available for nodes or components, as these do not have any operations.

The list in the left part allow to manage the operations. The buttons are the same as for the attributes (see above).

The fields in the right part allow to modify the operation selected in the list. The text for the operation will be:

visibility name(*parameters*) : *return-type* {*property-string*}

where *parameters* is a comma-separated list of parameters formatted as follows:

direction name : *type* = *default-value*

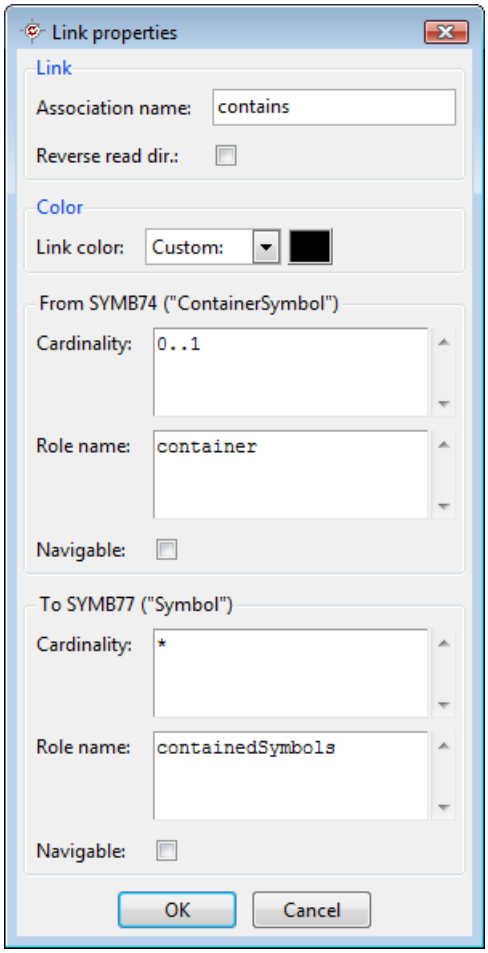
The visibility is rendered as the standard UML character ('+' for public, '#' for protected and '-' for private). The return type and property string for the operation and the type and default value for the parameters are included only if they are not empty.

Constructors and destructor are defined with the UML stereotypes: `<<create>>` and `<<delete>>`.

Any modified operation will be automatically updated in the operations text in the "Text" tab.

2.4.2 Link properties

Specific properties for association, aggregation and composition links may be modified via their property sheet:



In addition to the link name and color, the read direction for the link may be modified: if the "Reverse read dir." check-box is checked, the link should be read from the "To" class symbol to the "From" class symbol.

For both class symbols at the ends of the link, the dialog allows to modify the cardinality if available, the role name and the navigability. The rules for the navigability are those defined by UML:

- If the navigability is the same for both ends of the link (either on *or off*), each class will have an attribute representing the association.
- If the navigability is on only for the "From" (rep. "To") class symbol, only the "To" (resp. "From") class symbol will have an attribute for the association.

2.4.3 Access to generated C++ files

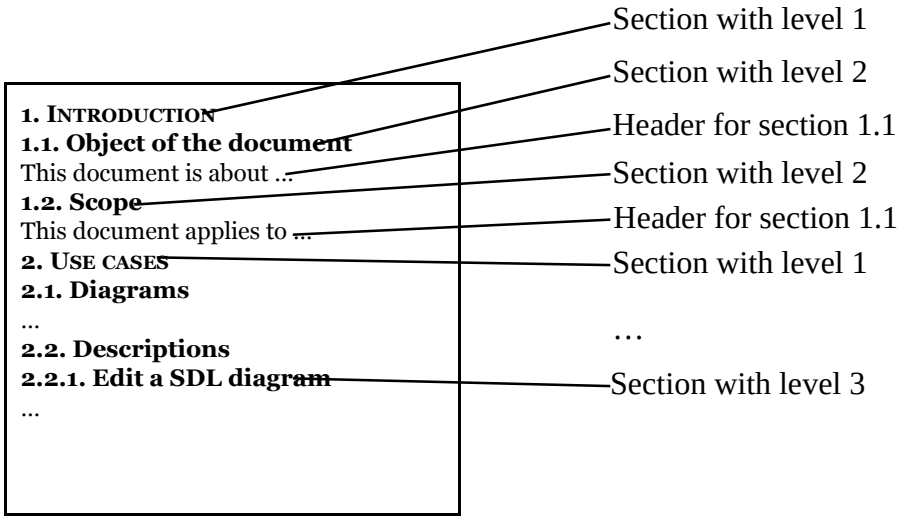
Double-clicking on a class symbol in a class diagram opens the generated C++ file for the class if there is one. Please note the file is not generated if it does not yet exist.

3 - Document editor

RTDS's way of handling documents is a bit different from what one can find in word processors. In a word processor, a document is just a set of paragraphs, usually having a style - named or not -, and each paragraph typically contains ranges of characters, optionally styled, and/or images. There is sometimes a notion of document structure in terms of chapters, containing sub-chapters, containing sections, and so on, but this structure is deduced from the paragraphs.

On the contrary, RTDS mainly uses the structure: a document is a set of chapters, sub-chapters, and so on, and the styles applied to the paragraphs are deduced from the structure. More precisely:

- A document is defined as a tree of sections. The top-level sections are the chapters; the ones under the chapters are the sub-chapters, and so on...
- Each section also has a section header, which is the text and images that will appear in the section *before* its sub-sections.



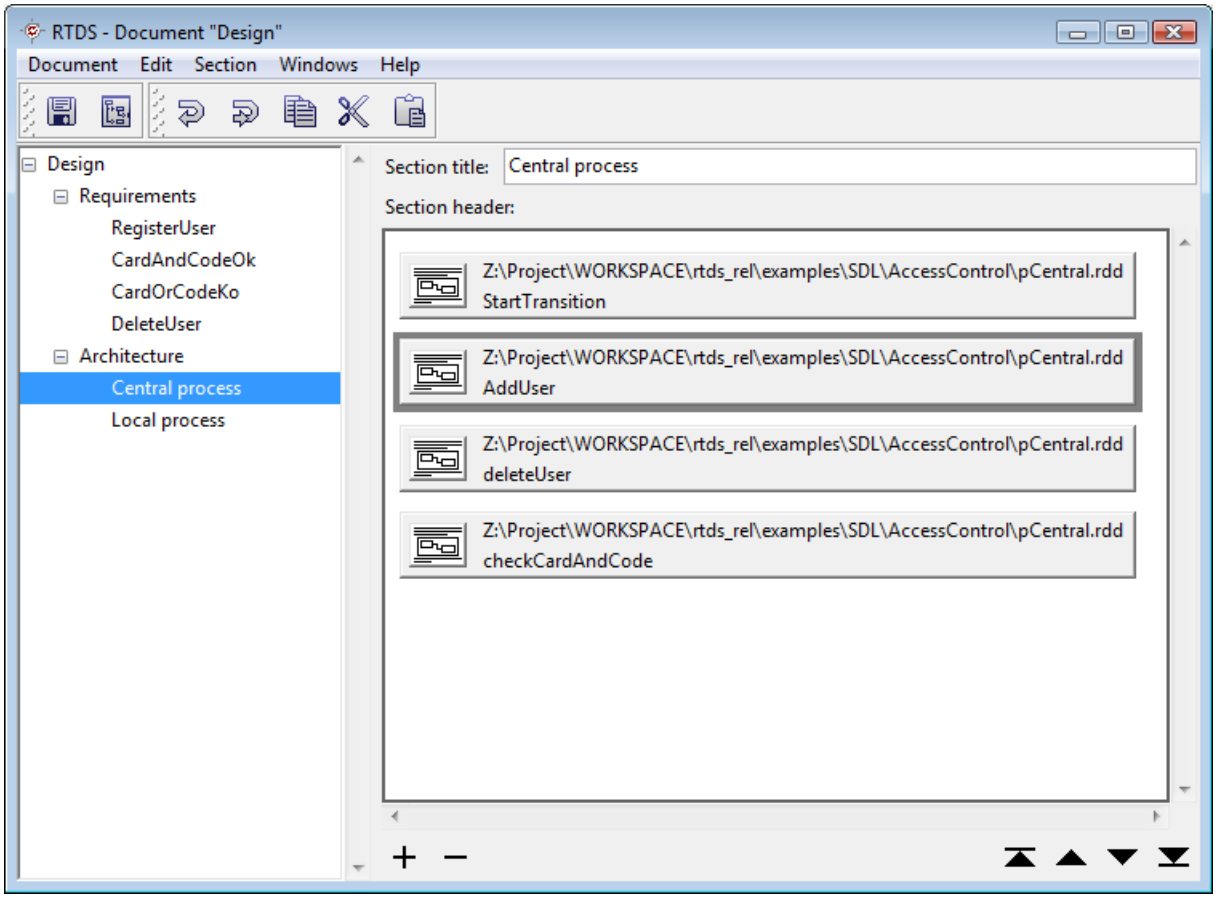
A section header is composed of header items, which can be:

- Text items: these items just contain styled text.
- Publication items: these items are references to publications in diagrams, as described in "Publications" on page 54. Such a header item will automatically include in the document:
  - The text before the publication if any;
  - The part of the diagram that is exported via the publication;
  - The text after the publication if any.
- Table items: these items contains a table, each of the table cells being a text item.
- External picture items: these items reference an image in a PNG file.
- External file items: these items just include the contents of an external file in the document, all text having a given style.

This allows to document the diagrams "on the fly" when the need arises by creating a publication and entering the texts before and after it. When the final document is written, it will just gather the parts already documented via publications, maybe with some additional explanation texts in text, external picture or table header items.

A fully documented system is available in the example files delivered with RTDS. It can be found under RTDS installation directory (`$RTDS_HOME`), under `examples/SDL/AccessControl`.

Here is a typical view of the document editor:

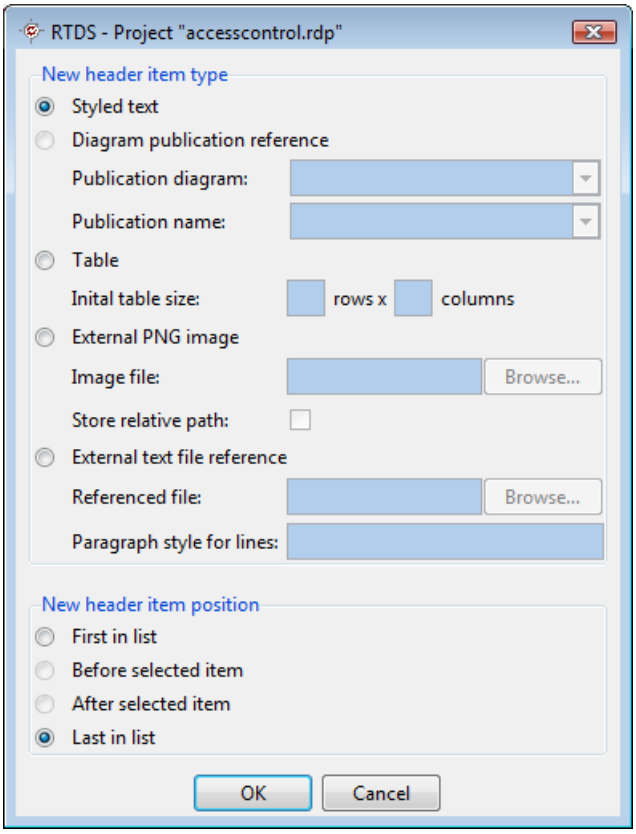


The left part of the window shows the section tree for the document, and the right part shows a text field allowing to change the selected section title and the list of its header items.

Sections can be added or removed from the section tree by using the "Section" menu, or the contextual menu in the section tree (right-click). The section tree can be rearranged via drag and drop.

Existing header items may be rearranged via the arrow buttons in the right-bottom corner of the window, or deleted via the '-' button. Header items can also be copied, cut and pasted from section to section, or even from document to document.

New header items can be added by selecting "New header item..." in the "Section" menu, or by clicking the '+' button in the lower part of the window. This opens the following dialog:

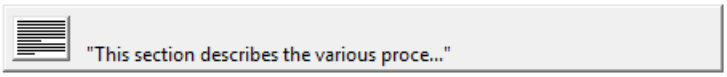


The upper zone allows to choose the type of header item to insert - text, publication, table, external image or external text file - and all required information for the header item:

- The parent diagram and the publication name for publication items. Note that only publications for currently opened diagrams are shown in the dialog, so the parent diagram for the publication to insert has to be opened before trying to add the header item.
- The initial number of rows and columns in table items.
- For external picture items, the file name for the referenced PNG image file and whether its path should be remembered as an absolute or a relative path from the document file's parent directory.
- For external text file items, the name of the file to include and the paragraph style to use for its text.

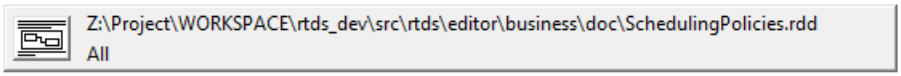
The lower zone in the dialog allows to specify where the new item will appear.

Once created, a text header item will appear like this:



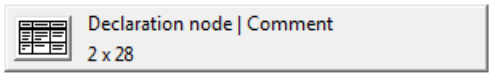
The text in the item is the beginning of the text actually entered in the item.

Publication header items will appear like this:



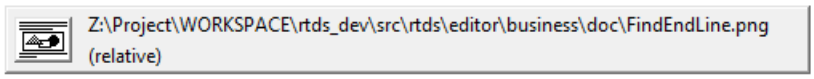
The first line of text is the diagram file name, and the second one is the publication name.

Table items will appear like this:



The first line includes the first table header line if any and the second one gives the table size.

External picture items will appear like this:



The first line is the full path of the referenced PNG file and the second line indicates if the reference is absolute or relative.

From the document editor window, it is also possible to export a document to a format that a word processor can handle. This is in fact the only way to get a form of the document that can be displayed or printed. The formats available today are:

- RTF, which can be used with all the major word processors;
- OpenDocument format, which is an ISO-standard for text documents, mainly used by OpenOffice.org and other open-source word processors;
- SGML; this format is for advanced users and won't be described further in this document. Please refer to the corresponding section in the reference manual for further details.

To be able to export a document in these formats, RTDS needs to attach presentation attributes to the texts in the document. This is done via documentation display and export options, which are displayed in the following paragraphs.

3.1 - Documentation display options

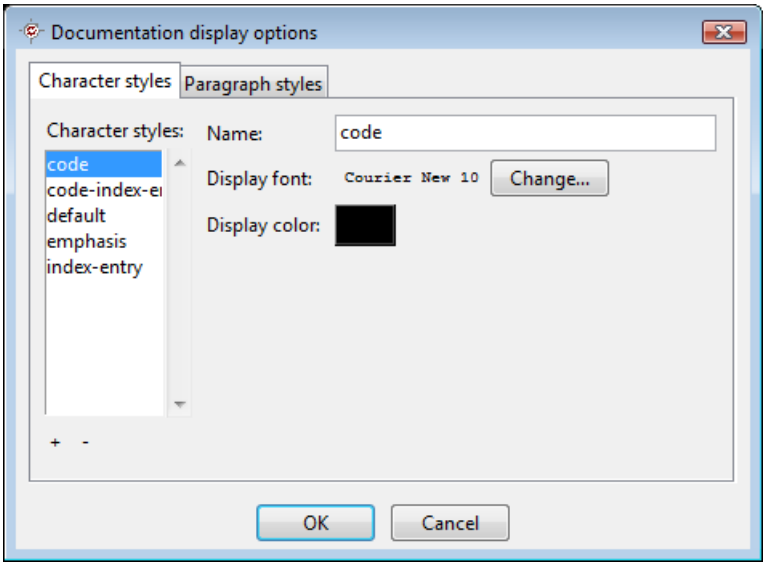
The documentation display options have two main objectives:

- Define what styles are available in publication texts and document section header text items;
- How these styles will be displayed on screen in the editors.

There are two types of styles:

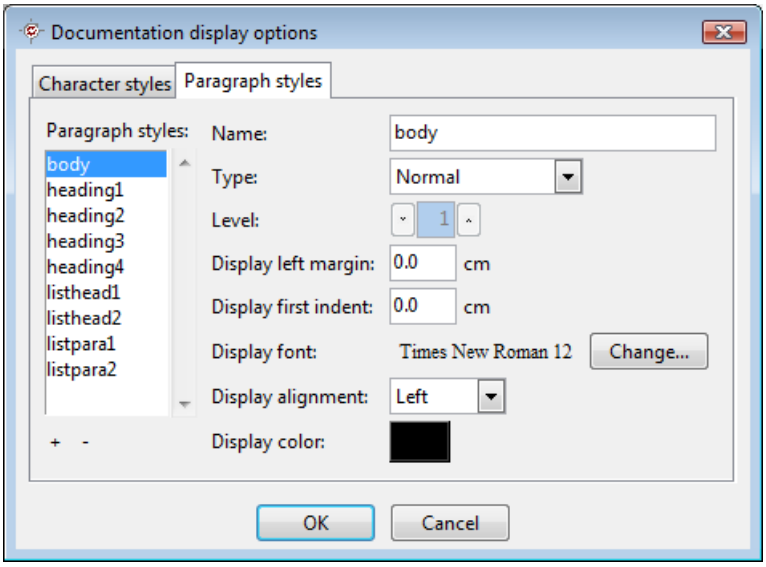
- Paragraph styles define the appearance for whole paragraphs. This concept is the same as the usual styles found in word processors. Typical display options for paragraphs include the font for the paragraph text, its margins, its alignment, and so on...
- Character styles define the appearance for range of characters within paragraphs. Display options for these styles are just a font (with its family, its size and its style) and a color.

Documentation display options are defined in a project, so that all styles will be available in all diagrams and all documents contained in the project. Setting these display options is done in the project manager window via the "File" menu, item "Documentation display options...". The following dialog appears:



The first tab in the dialog allows to define character styles. Clicking on the "+" button under the list creates a new style by copying the selected one; clicking the "-" button deletes the selected style. The right part of the dialog allows to change the style name and to define the font and color for the characters with this style.

The second tab in the dialog allows to define the paragraph styles and looks like this:



Styles are created and deleted just as character styles. The style options are:

- Its name;
- Its type. A paragraph style may be either a normal paragraph in a text body, a list header, a paragraph inside a list or a style for section headings.
- Its level. This option is not used for normal paragraphs in a text body. For the other types:
  - For section headings, the level is the section level;

- For list headers or paragraphs in lists, the level is the list level.

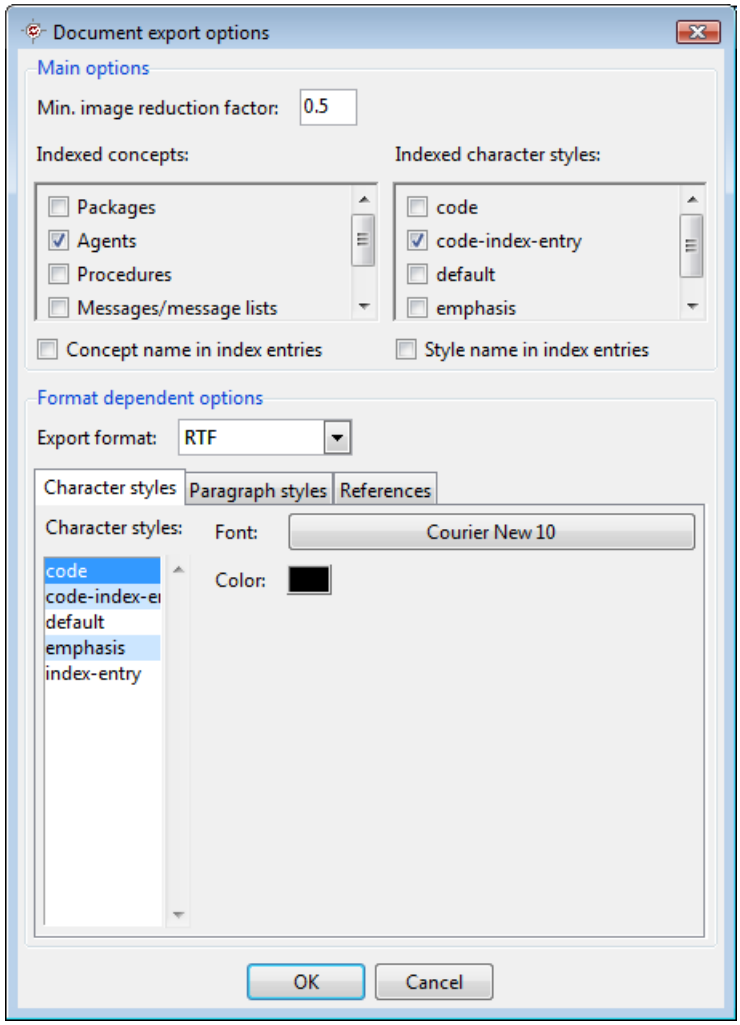
  Please note that RTDS is more strict than other word processors: it won't let you create a list with a level set to 3 after a normal paragraph, or directly inside a list with level 1.
- Its left margin. This is the distance in centimeters from the left border of the text editor to the position from which the text starts.
- Its first indent. It is the distance in centimeters from the left margin to the position from which the text of the paragraph's first line starts. For normal paragraphs, it is usually 0. For list headers, it is usually negative to add some space for the bullet or list number. It may also be used for section headings to set a fixed width for the section number.
- The font for its characters, including the font family, its size and its style (bold, italic, underlined).
- The alignment for the paragraph: left-aligned, right-aligned or centered. Please note that full justification is not available in the editors. It is only available in export styles (see "Documentation export options" on page 96).
- The color for the paragraph's text.

NB: Styles for section heading paragraphs must be defined here, but they will not be directly available in editors, since the section headings should be defined via the document structure, and not directly within texts. The display options defined for these styles are also not significant today, as the document sections are never displayed as styled texts.

3.2 - Documentation export options

Display styles are only used when displaying styled texts on screen. When exporting a document to a format usable in a word processor, more options are available. These options are defined via the documentation export styles. The export styles are also attached to a project.

Defining export styles is done in the project manager by selecting the "Documentation export styles..." in the "File" menu. This opens the following dialog:



The upper zone in the dialog defines some options that are not dependant on the export format:

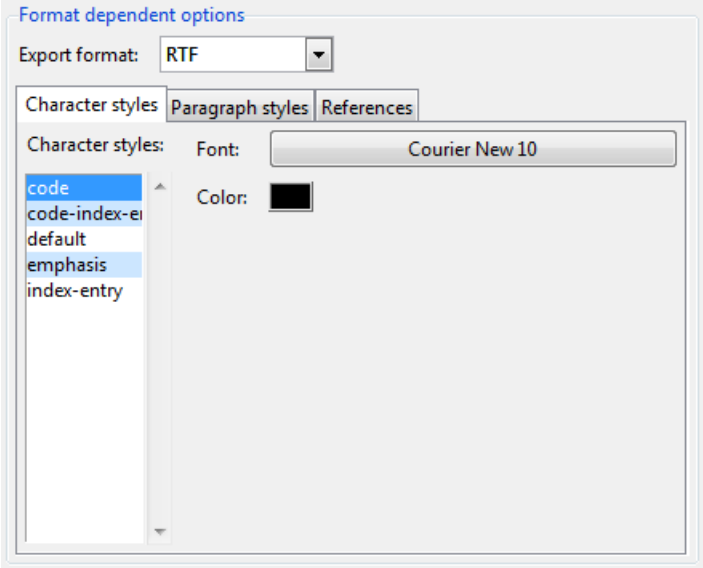
- The minimum image reduction factor defines how images built from diagram publications will be sized when included in the exported document. The default is to adapt the image size to the width and/or height of the page. This option allows to specify that images should always be reduced by this factor before doing any other adaptation.
- The next two tables allows to automatically set up an index in the exported document:
  - The left-most table defines what are the concepts that will automatically be included in the document index. These index entries will be figured out automatically by RTDS each time an image from a diagram publication is exported. If this image includes any concept checked in this list, an index entry will be automatically set up, with the concept name as its text, referring this image in the document. Available concepts are packages, agents, procedures, messages and message lists, passive classes, class attributes, class operations and semaphores (in SDL-RT projects).

- The right-most table defines a set of character styles that will also automatically be included in the document index. The text for the entry will be the whole text with this style. This allows to explicitely define index entries in any text.
  NB:
  - This is actually the only way to define "custom" index entries today.
  - This may lead to duplicate existing character styles to be able to define the index. For example, a character style can be defined for bits of code in a document, with typically a fixed-width font. If class, attribute or operation names are included in the text, and if the index should reference these names, it is possible to duplicate the `code` style to a style named `indexed_code` for example, and to use `indexed_code` for all these names.

Below these two tables are options to create "extended" index entries. These entries will not only include the text for the entry, but also a short description of what it is (concept name for concepts, style name for character styles).

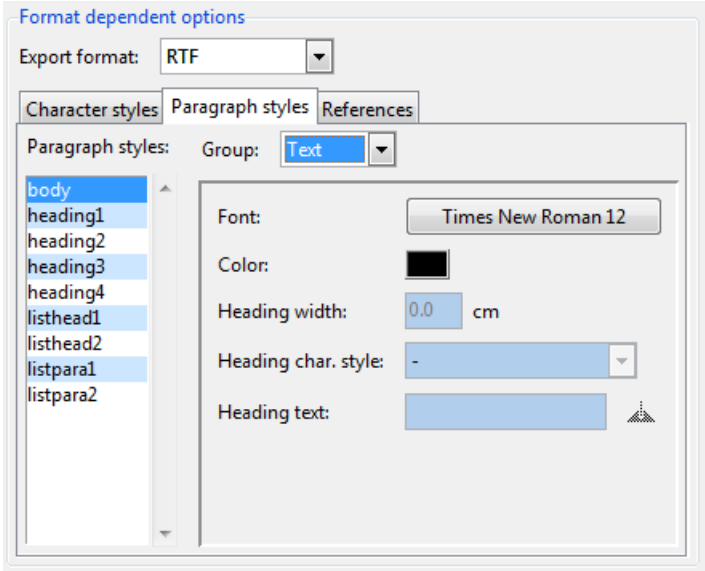
The lower zone in the dialog defines the options that depend on the format used for export, arranged in tabs:

- The first tab shows the export options for the character styles:



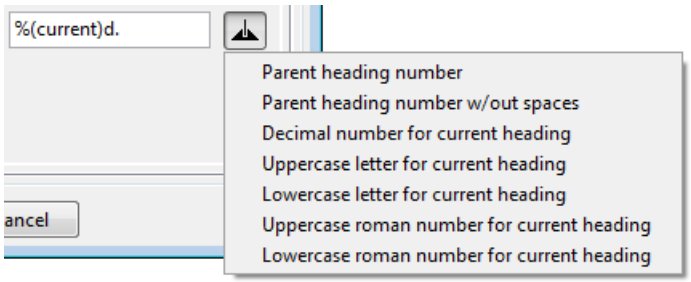
The list in the left part shows the available character styles, as defined in the documentation display options. Please note that you cannot add, remove or rename styles here; they have to be removed from the display options (see “Documentation display options” on page 94).
The right part allows to change the actual export style for the character style, which is only the font and the color.

- The second tab shows the export options for the paragraph styles:

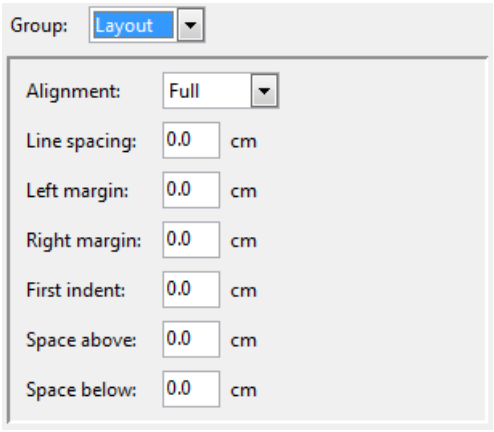


As for character styles, the list in the right part shows the list of available paragraph styles. Again, the available styles are defined via the documentation display options and cannot be added, removed or renamed here (see “Documentation display options” on page 94).
The right part shows the export options for the paragraph style. As there are many options, they are organized into groups:

- The "Text" group (shown above) includes the options for the text itself, including its font, its color, and the heading to automatically include in the paragraph if any. This heading is only available in section heading and list header paragraphs:
  - The heading width should be set only if the heading has a fixed width, typically for list headers.
  - The heading character style may be used to give a different style to the heading text. This may be typically used for list bullets.
  - The heading text may contain markers for the section or list number in many formats, and the number for the parent section or list. These markers don’t need to be explicitely typed and can be entered by using the menu available via the button:


%(current)d.
Parent heading number
Parent heading number w/out spaces
Decimal number for current heading
Uppercase letter for current heading
Lowercase letter for current heading
Uppercase roman number for current heading
Lowercase roman number for current heading
ancel

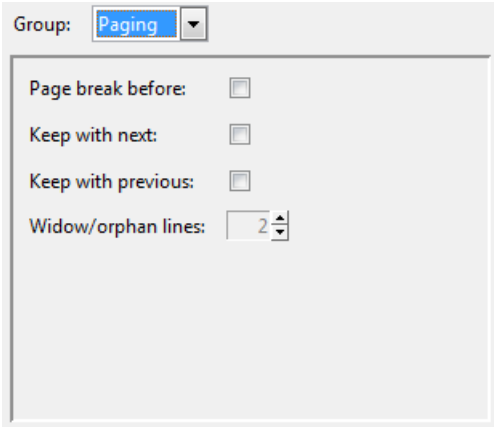
- The "Layout" group includes the options for the text layout on the page:



These options are quite usual:
- alignment (including the fully justified option),
- additional line spacing (that can be negative to make lines less high),
- left margin (from the page left border),
- right margin (from the page right border),
- first line indent (from the left margin),
- additional space above paragraph,
- additional space below paragraph.

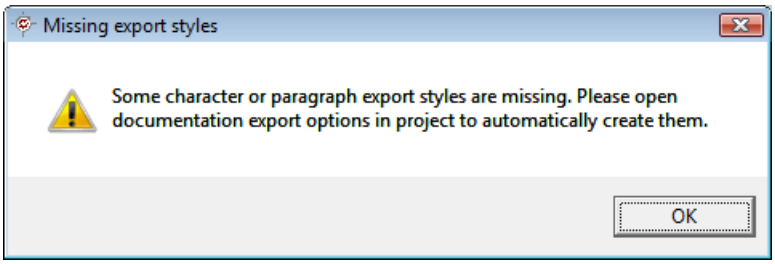
All distances are specified in centimeters.

- The "Paging" group allows to specify the options that have an impacts on how page breaks will be handled:



  - "Page break before" always forces a page break before a paragraph with this style.
  - "Keep with next" forces the paragraph to be on the same page as the one following it.
  - "Keep with previous" forces the paragraph to be on the same page as the one preceding it. Please note some formats or word processors may not be able to take this option into account.
  - "Widow/orphan lines" specifies the minimum number of lines that are allowed to stay alone on one page for the paragraph.
- The third tab shows the format for cross-references. This format is not used today.

Export styles should be defined for all available styles in all export formats. If some export styles are missing, a warning will be displayed when any document is opened:

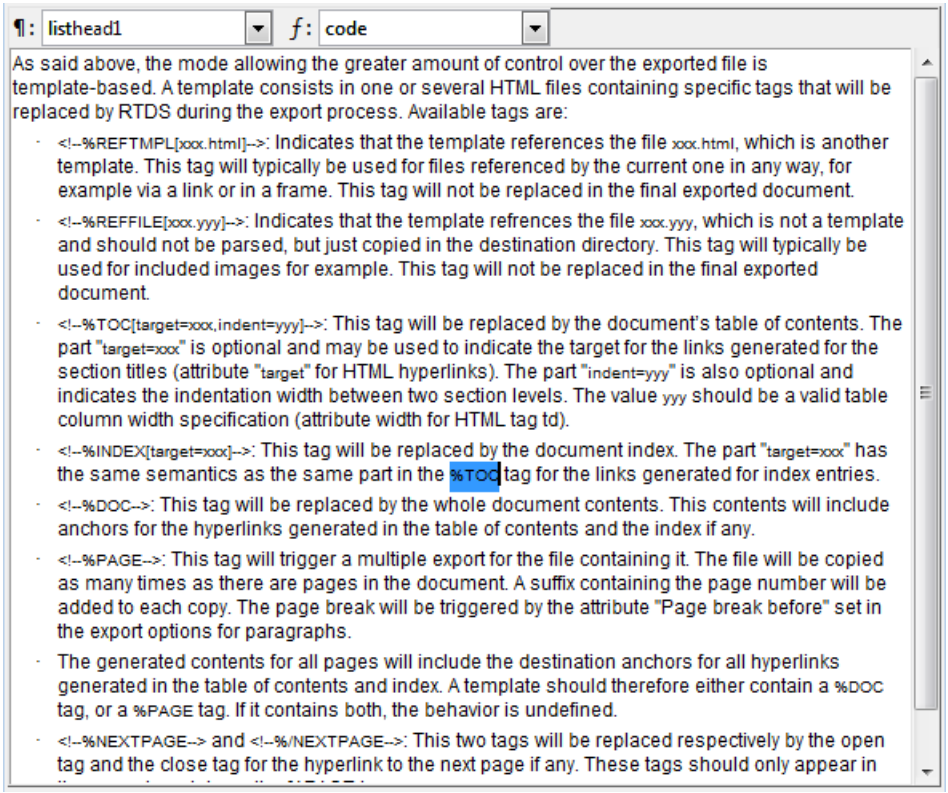

Missing export styles
Some character or paragraph export styles are missing. Please open documentation export options in project to automatically create them.
OK

Opening the export options for the project will then create automatically the missing styles if you ask for it. Please note that the options set up for the export styles are copied from the display style if available, or set to default values. This may not be what you want, so the automatically created styles should be reviewed and updated where needed.

NB: As RTDS works today, export styles are not used when exporting to OpenDocument format. This kind of export is actually based on a document template, from which the styles are imported. So you just have to make sure that all character and paragraph styles in RTDS also exist in the template document with the same name.

3.3 - Styled text editor

Once the styles are set up, they will be available in all editors for texts, either in publications or in section header items. Such an editor is shown below:


¶: listhead1
ƒ: code
As said above, the mode allowing the greater amount of control over the exported file is template-based. A template consists in one or several HTML files containing specific tags that will be replaced by RTDS during the export process. Available tags are:
<!--%REFTMPL[xxx.html]-->: Indicates that the template references the file xxx.html, which is another template. This tag will typically be used for files referenced by the current one in any way, for example via a link or in a frame. This tag will not be replaced in the final exported document.
<!--%REFFILE[xxx.yyy]-->: Indicates that the template refrences the file xxx.yyy, which is not a template and should not be parsed, but just copied in the destination directory. This tag will typically be used for included images for example. This tag will not be replaced in the final exported document.
<!--%TOC[target=xxx,indent=yyy]-->: This tag will be replaced by the document's table of contents. The part "target=xxx" is optional and may be used to indicate the target for the links generated for the section titles (attribute "target" for HTML hyperlinks). The part "indent=yyy" is also optional and indicates the indentation width between two section levels. The value yyy should be a valid table column width specification (attribute width for HTML tag td).
<!--%INDEX[target=xxx]-->: This tag will be replaced by the document index. The part "target=xxx" has the same semantics as the same part in the %TOC tag for the links generated for index entries.
<!--%DOC-->: This tag will be replaced by the whole document contents. This contents will include anchors for the hyperlinks generated in the table of contents and the index if any.
<!--%PAGE-->: This tag will trigger a multiple export for the file containing it. The file will be copied as many times as there are pages in the document. A suffix containing the page number will be added to each copy. The page break will be triggered by the attribute "Page break before" set in the export options for paragraphs.
The generated contents for all pages will include the destination anchors for all hyperlinks generated in the table of contents and index. A template should therefore either contain a %DOC tag, or a %PAGE tag. If it contains both, the behavior is undefined.
<!--%NEXTPAGE--> and <!--%/NEXTPAGE-->: This two tags will be replaced respectively by the open tag and the close tag for the hyperlink to the next page if any. These tags should only appear in

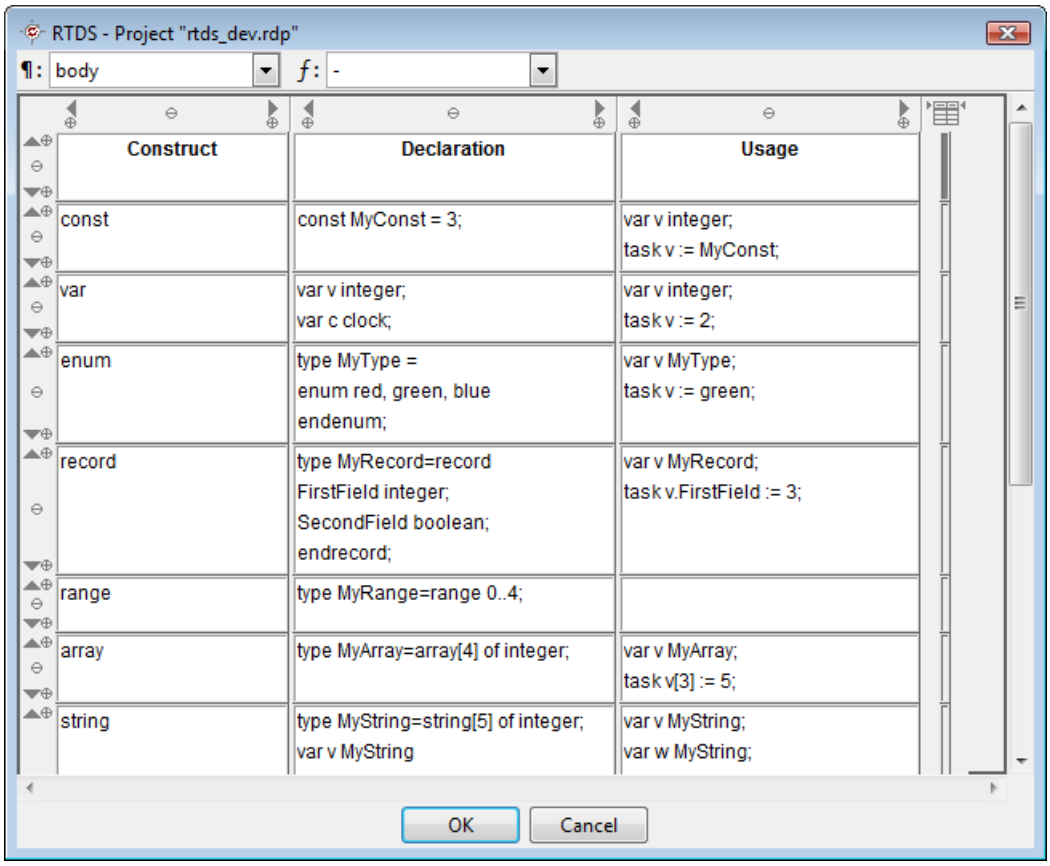
The bottom zone contains the actual text. The menus at the top allow to select:

- The paragraph style ("¶"). This style is applied to the current paragraph or to all selected paragraphs.
- The character style ("*f*"). This style is applied to the selected characters.

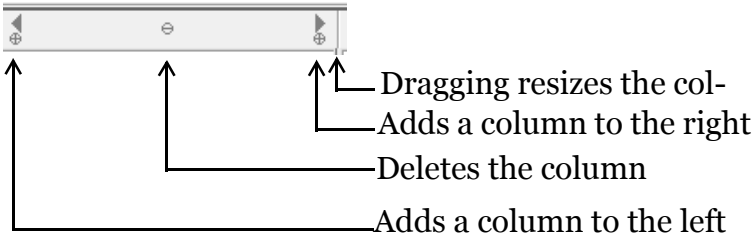
Note that not all paragraph styles are available in all contexts: as said in “Documentation display options” on page 94, RTDS is more strict than usual word processors and will not allow to create inconsistent list nesting (like a paragraph inside a list with level 2 just after a list header with level 1). Trying to do an operation on the text that would create such an inconsistency will be refused.

3.4 - Table editor

Double-clicking on a table header item in a document section opens it in an editor such as the following one:



All table cells are editable as normal styled texts, except the paragraph and character style selectors are above the table. Navigating through table cells via the tab and shift-tab keys is possible. Columns can be manipulated via their header:



Adding and deleting rows is done via the similar buttons in the row header.

The special column allows to define the header rows for the table: clicking on the for a given row makes it the last row in the table header.

3.5 - Exporting documents

3.5.1 Exporting as RTF

Exporting a document as an RTF file is quite straightforward: just select "Export as..." -> "RTF" in the "Document" menu of the document editor window. RTDS will ask for the file to export to, then export the document to that file.

3.5.2 Exporting as OpenDocument format

As said in “Documentation export options” on page 96, RTDS does not actually use the export styles defined in the document when exporting to OpenDocument format. The styles are taken from a template, which is another file in OpenDocument format. So selecting "Export as..." -> "OpenDocument" in the "Document" menu in the document editor will open a dialog asking for the destination file and the document template. Once both files are specified, RTDS will export the document to the specified destination file.

3.5.3 Exporting as HTML

There are some limitations on the options actually taken into account for styles when exporting to HTML:

- The minimum image reduction factor is actually used to create thumbnails for images in the document. If set to less than 1, thumbnails will be created and inserted in the exported HTML file, with a link to the actual image with the full size.
- The font and text color specified in paragraph styles is not used today.
- The heading width is never used.
- Heading texts are only used for section headings. Those specified for lists are not used, as HTML provides its own list bullets or numbers. RTDS only uses the heading text to try to figure out if a list should be bulleted or numbered.
- The "Full" alignment is replaced by "Left", as full justification is not available in HTML.
- All margins and spacings are not used.
- The "Page break before" option is only used in some cases (see below).
- The other options related to pagination are not used as they are meaningless in HTML.

There are actually two kinds of HTML exports available:

- The first is the basic one, exporting the whole document to a single HTML file. In this mode, no table of contents or index is generated. This is the mode used when no template is specified for the export.

- The second mode allows much more control over the files that will be actually exported, and must be used if a table of contents or index is needed. This kind of export is based on templates.

Both modes actually export several files, including at least the main HTML file and the exported images (in PNG format). So exporting to HTML from the document editor will actually ask for a destination directory where all the files will be created. To prevent files from being overwritten by the export, RTDS will issue a warning if the chosen directory is not empty.

As said above, the mode allowing the greater amount of control over the exported file is template-based. A template consists in one or several HTML files containing specific tags that will be replaced by RTDS during the export process. Available tags are:

- `<!--%REFTMPL[`*`xxx.html`*`]-->`: Indicates that the template references the file *`xxx.html`*, which is another template. This tag will typically be used for files referenced by the current one in any way, for example via a link or in a frame. This tag will not be replaced in the final exported document.
- `<!--%REFFILE[`*`xxx.yyy`*`]-->`: Indicates that the template refrences the file *`xxx.yyy`*, which is not a template and should not be parsed, but just copied in the destination directory. This tag will typically be used for included images for example. This tag will not be replaced in the final exported document.
- `<!--%TOC[target=`*`xxx`*`,indent=`*`yyy`*`]-->`: This tag will be replaced by the document's table of contents. The part "`target=`*`xxx`*" is optional and may be used to indicate the target for the links generated for the section titles (attribute "`target`" for HTML hyperlinks). The part "`indent=`*`yyy`*" is also optional and indicates the indentation width between two section levels. The value *`yyy`* should be a valid table column width specification (attribute `width` for HTML tag `td`).
- `<!--%INDEX[target=`*`xxx`*`]-->`: This tag will be replaced by the document index. The part "`target=`*`xxx`*" has the same semantics as the same part in the `%TOC` tag for the links generated for index entries.
- `<!--%DOC-->`: This tag will be replaced by the whole document contents. This contents will include anchors for the hyperlinks generated in the table of contents and the index if any.
- `<!--%PAGE-->`: This tag will trigger a multiple export for the file containing it. The file will be copied as many times as there are pages in the document. A suffix containing the page number will be added to each copy. The page break will be triggered by the attribute "Page break before" set in the export options for paragraphs.
  The generated contents for all pages will include the destination anchors for all hyperlinks generated in the table of contents and index. A template should therefore either contain a `%DOC` tag, or a `%PAGE` tag. If it contains both, the behavior is undefined.
- `<!--%NEXTPAGE-->` et `<!--%/NEXTPAGE-->`: This two tags will be replaced respectively by the open tag and the close tag for the hyperlink to the next page if any. These tags should only appear in the same template as the `%PAGE` tag.
- `<!--%PREVPAGE-->` et `<!--%/PREVPAGE-->`: Same as the `NEXTPAGE` tags, but for the previous page.

All these tags must be alone on a line, with only whitespace before or after it, but not within.

The template is actually composed of the top-level template file specified in the HTML export dialog, plus all the file it references via a `%REFTMPL` or a `%REFFILE` tag, plus all files referenced via a `%REFTMPL` or a `%REFFILE` tag in these ones, etc... All these files will be copied to the destination directory for the export, and only these ones. So any file actually or potentially used by any of the templates *must* be referenced via a `%REFTMPL` or a `%REFFILE` tag, or it won't be copied and will be unavailable in the exported document.

An example template for HTML export is available in RTDS example projects, in `$RTDS_HOME/examples/SDL/AccessControl`.

3.6 - Using exported documents

When exporting a document to any format, RTDS will only export the document body. Usual things like a title page, a table of contents or the document index cannot be created by RTDS, since it can't know how to format them, or place them in the document.

It is however possible to create these items and link them with the document body created by RTDS in all tools. This section presents how to do such a thing with the two major word processors: Microsoft Word and OpenOffice.org.

3.6.1 In Microsoft Word via RTF

Dynamically adding things to the part of the document generated by RTDS in Microsoft Word is quite easy:

- Export the document body to a RTF file using the "Document" -> "Export as..." -> "RTF" menu in the document editor.
- In Microsoft Word, create a new empty document.
- Define the page layout that your document should have: page size, margins, header, footer and so on...
- Add to the document all pages that should be inserted before the document body created by RTDS. This would typically be a title page and a table of contents for example. If created here, the table of contents will be empty.
- At this point, do a dynamic insertion of the RTF file generated by RTDS by selecting the "Insert" -> "File..." menu. In the file selection dialog that appears, select RTF in the file types menu in the bottom, then select the RTF file created by RTDS. Then open the menu attached to the "Insert" button and select "Insert as link". This will dynamically import the RTF file within the Word document.
- After that, create all items that should go after the document body in your document, typically the index.
- Select everything in your document and ask to update the fields via the F9 key. If asked whether to update only page numbers or the whole table or index, select the second option.

That's all; you should now have a full document including everything needed. Whenever your document changes in RTDS, just export it again to the same RTF file, then open the Word document, select all and press F9.

3.6.2 In OpenOffice.org via OpenDocument format

Defining the items that should be added to the document body exported by RTDS in OpenOffice.org is done via a specific document type called a master document. This kind of documents may contain text and refer to other external documents as well. To define such a document, just select "New" -> "Master document" in OpenOffice.org Writer "File" menu. This will display a regular document window with a navigator window near it. This navigator window allows to add items in the master document.

The page setup - page size, margins, header(s), footer(s), and so on... - should be done directly in the master document.

Regular text, such as the title page, can be added directly in the master document window as in any regular document. Creating such a text will create a line labelled "Text" in the navigator window.

Inserting a table of contents should be done via the navigator window by selecting the line before the point where it should be inserted and selecting "Index" in the "Insert" menu (in OpenOffice.org 2.0, this menu is under the button). The standard index / table of contents insertion dialog will appear; just set up the options as you would in a normal document.

To include the document body exported by RTDS in the master document, select the item before the insertion position and select "File..." in the "Insert" menu. Select the file exported by RTDS and validate.

To add an index, the operations are the same as those to insert a table of contents.

NB: Once created, the master document will include a copy of all character and paragraph styles that were in the document exported by RTDS when it was inserted. Any following changes will only have an impact in the exported document, and *not* in the master document including it.

3.7 - Questions and answers

This section includes a number of questions that may arise when using the documentation system in RTDS with their answers.

Q: How can I create a "bold" or "italic" character style as in a word processor?

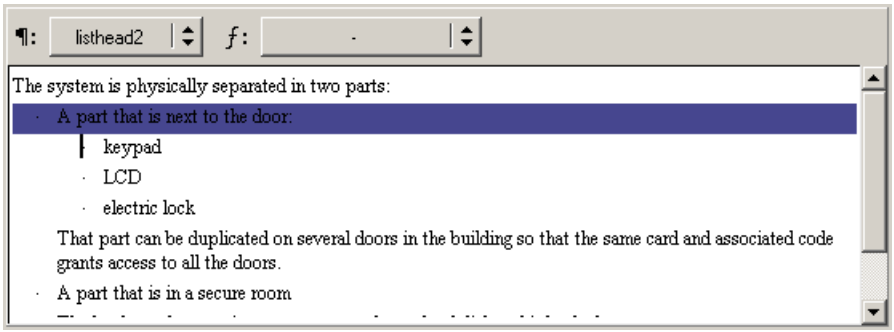
A: If the character style should just put the characters in boldface or in italic without any font change, you can't: character styles in RTDS *always* include a font family. If you plan to use the style in a regular text, just set the same font family as in your default paragraph style. If you mix several font families within the same document, you'll have to define several "bold" or "italic" character styles: one per font family that you're using.

Q: Several paragraph styles I've defined in the documentation display options do not appear in the styled text editors. Why?

A: All paragraph styles marked as section headings in display options ("Type" is "Heading") are intended to be used internally by RTDS for section titles when it exports a document to a given format. They should not be used directly in texts, so they won't appear in the paragraph styles menu in the styled text editors.

Q: I've selected some paragraphs in a styled text editor that I want to delete, but nothing happens when I hit the "Del" or "Backspace" key!

A: As said in "Documentation display options" on page 94, RTDS is quite strict when handling list nesting: you can't have a list with level 2 directly appearing after a normal paragraph, or have a paragraph declared as inside a list with level 2 appear after a list header with level 1. This is required to be able to export to structured document types such as HTML. If an operation would create an inconsistency in list nesting, RTDS will forbid it. So for example, if you have the following selection:


¶:
listhead2
ƒ:
The system is physically separated in two parts:
A part that is next to the door:
keypad
LCD
electric lock
That part can be duplicated on several doors in the building so that the same card and associated code grants access to all the doors.
A part that is in a secure room

RTDS will forbid the deletion, since it would make the "keypad" list header with level 2 appear just after the paragraph "The system is physically separated in two parts:", which is a normal paragraph not inside a list. So this would create an inconsistency in list nesting. Trying to delete this selection will therefore do nothing.

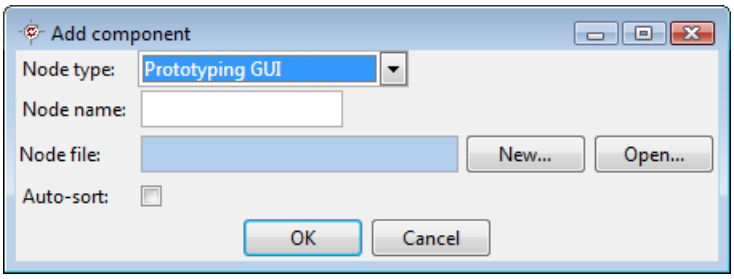
To be able to delete these paragraphs, you first have to change the styles for the paragraphs after the selection or before it to ensure that list nesting will be consistent after the deletion.

4 - Prototyping GUI

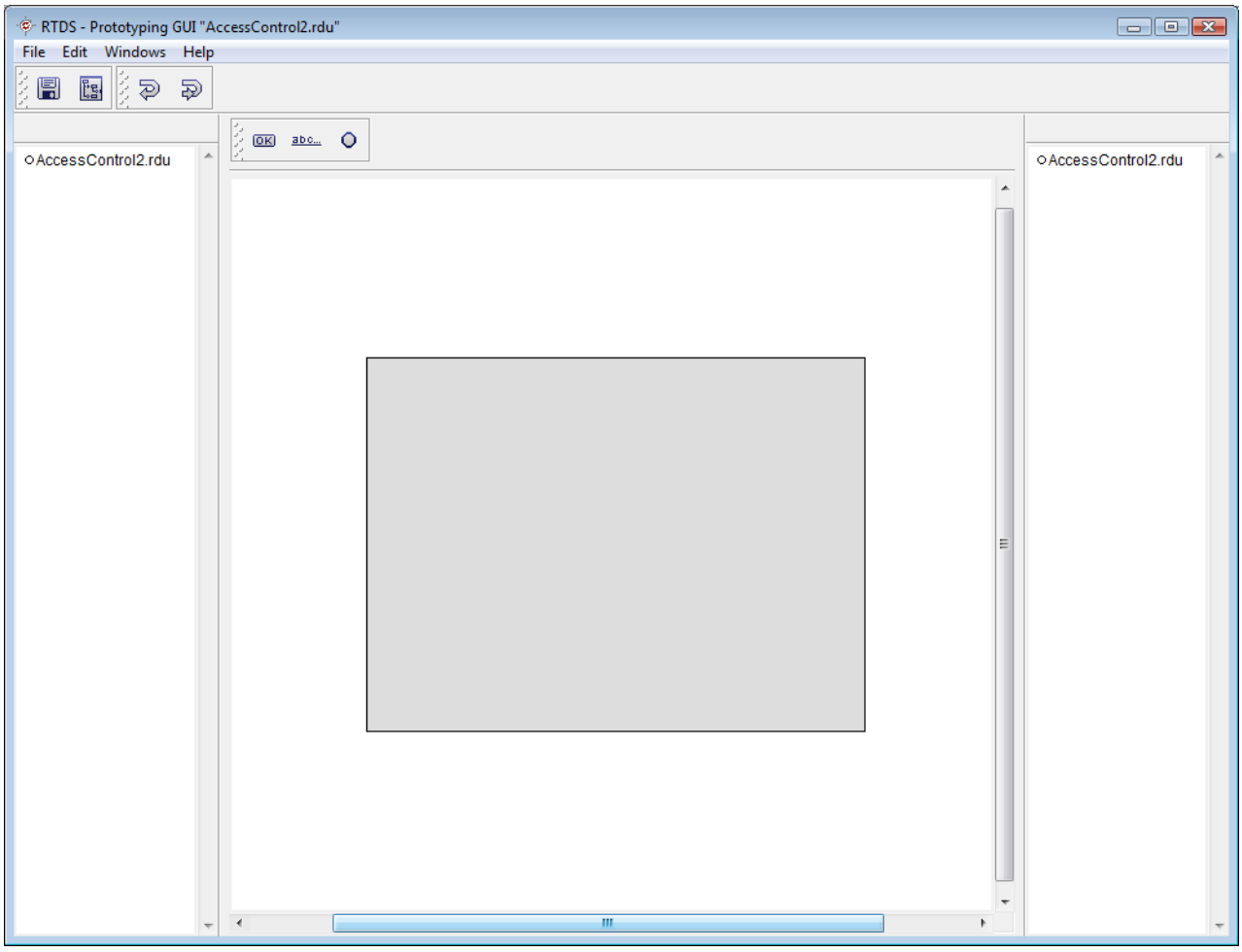
RTDS has a built-in GUI editor to ease model validation. This allows to describe a graphical interface that will interact with the model.

4.1 - Prototyping GUI editor

Insert a prototyping GUI element in the project.



A new empty GUI editor will open:



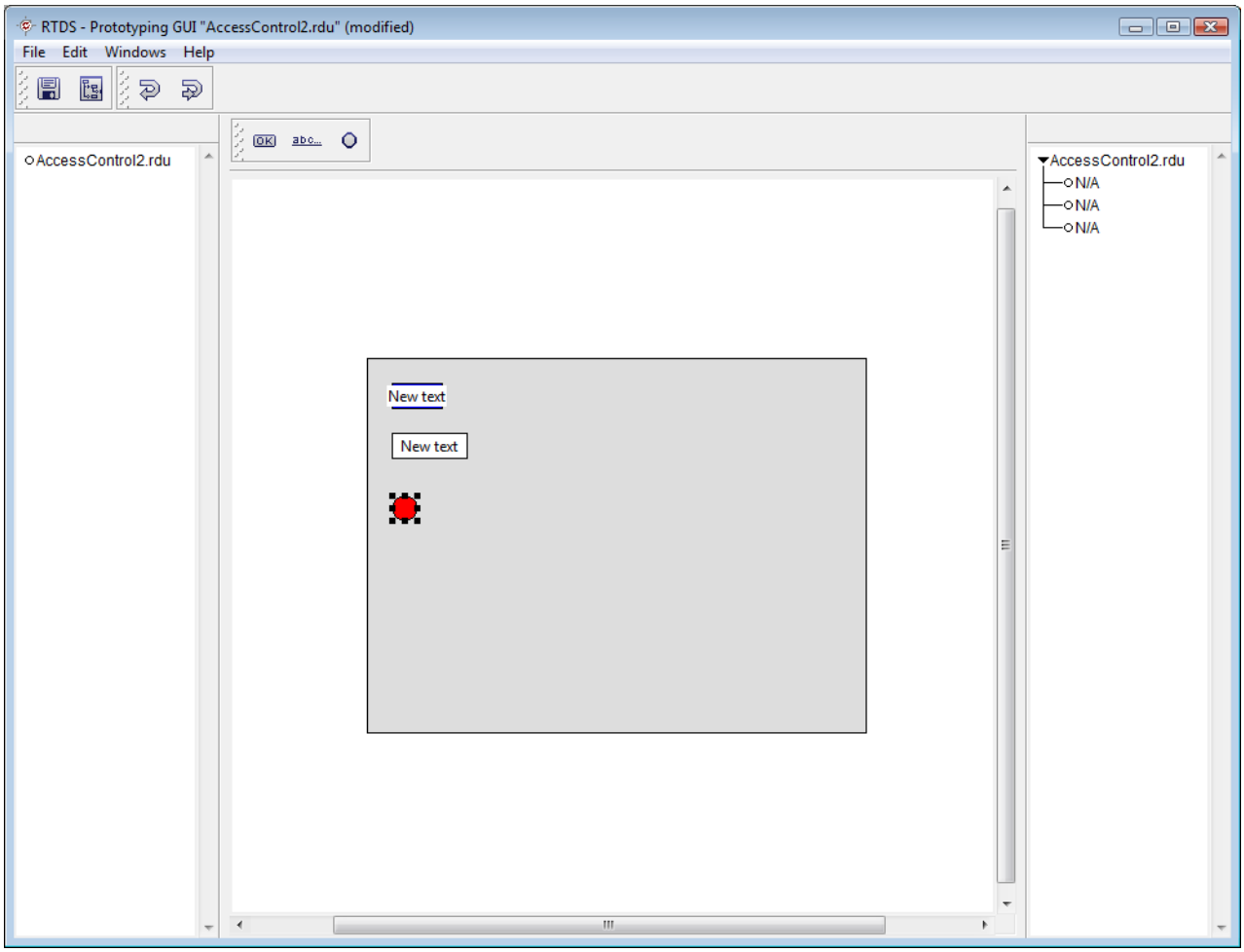
The editor is divided in three parts:

- The trigger tree on the left,
  This tree will describe which events will trigger actions on the display.
- The graphical layout in the middle,
  This area is to design what the GUI will look like.
- The output tree on the right.
  This tree will describe the actions to be executed when the GUI is stimulated.

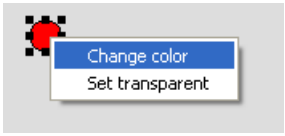
In the middle area three types of graphical elements can be inserted: buttons, text displays, and LEDs.

Each time one of these elements is inserted, a corresponding tree item is added in the right area.

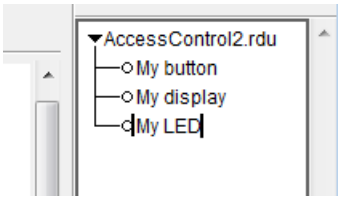
Let's consider for example we are adding one of each widget in the display:



Right click on the widget to change its color:

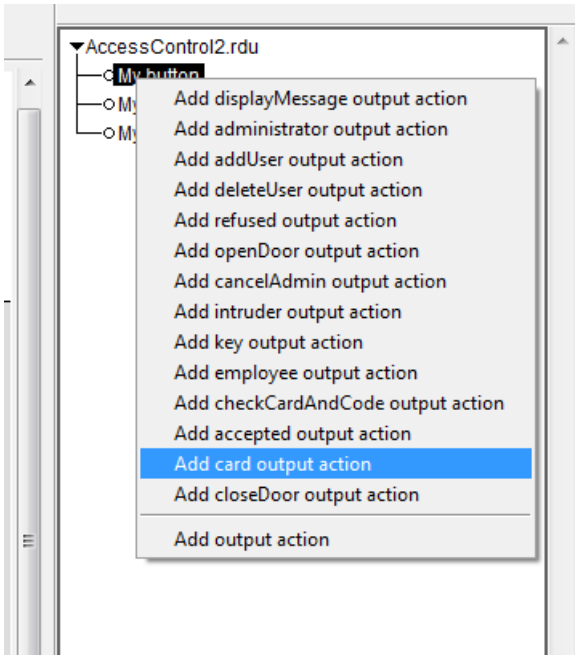


Double-clicking on the name in the tree to edit the name of the widget:



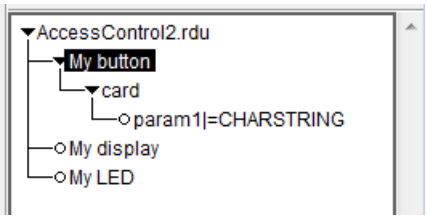
Double-clik on the widget text to edit it:

A text display and a LED generally do not generate any output action. Let's add an action to the Admin button: right click on the corresponding element in the output tree and all the available message in the system will be displayed:

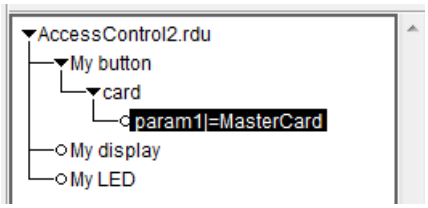


In this example, we are using the Access Controle SDL Z.100 example. Let's say the 'card' message will be sent to the system when the user click on 'My button'. The parameters

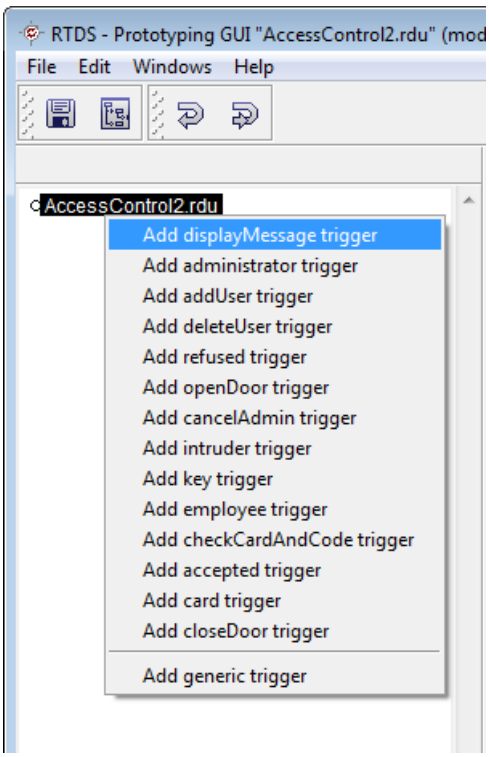
associated with the message will be automatically displayed and the expected type is diplayed to ease editing.



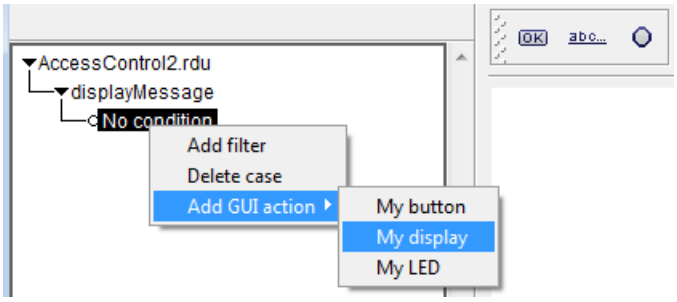
In that example the administrator card should have 'MasterCard' as its parameter. Double click on the type and enter the desired parameter value:



Let's now consider the incoming display message parameter value is to be displayed in the text display widget. Let's get to the trigger tree and create a case:



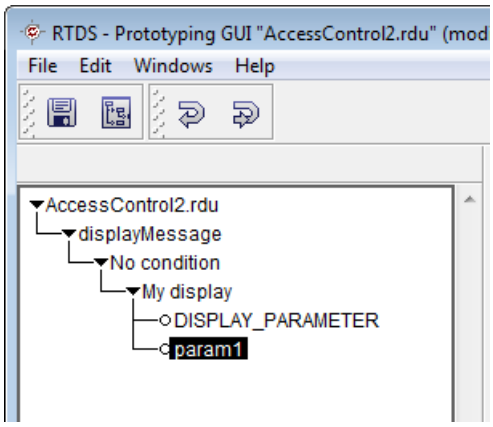
In the new element, it is now possible to add cases. Each case is a set of filters to be verified and actions to do when the filters are verified. In our case, we will not have any filter since we want to display the parameter value all the time.



The syntax to access parameter value has the following form:

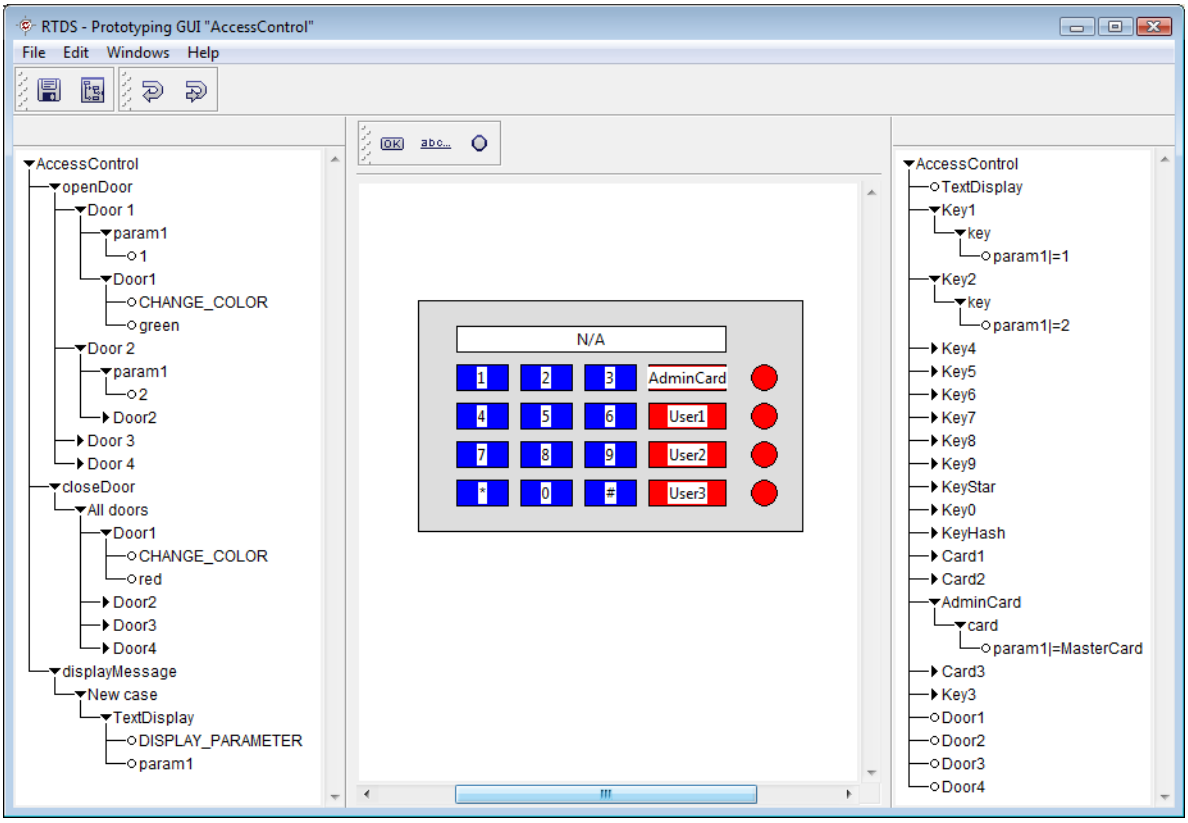
```
param<number>{.<field name>]}*
```

In our example we just need to access the value of parameter 1:



We could also use the DISPLAY type of action to display a specific text that has nothing to do with the parameters value.

Let's have a look at some other cases with the Access Control example:



In this example the three triggers: open, close, and displayMessage are considered.

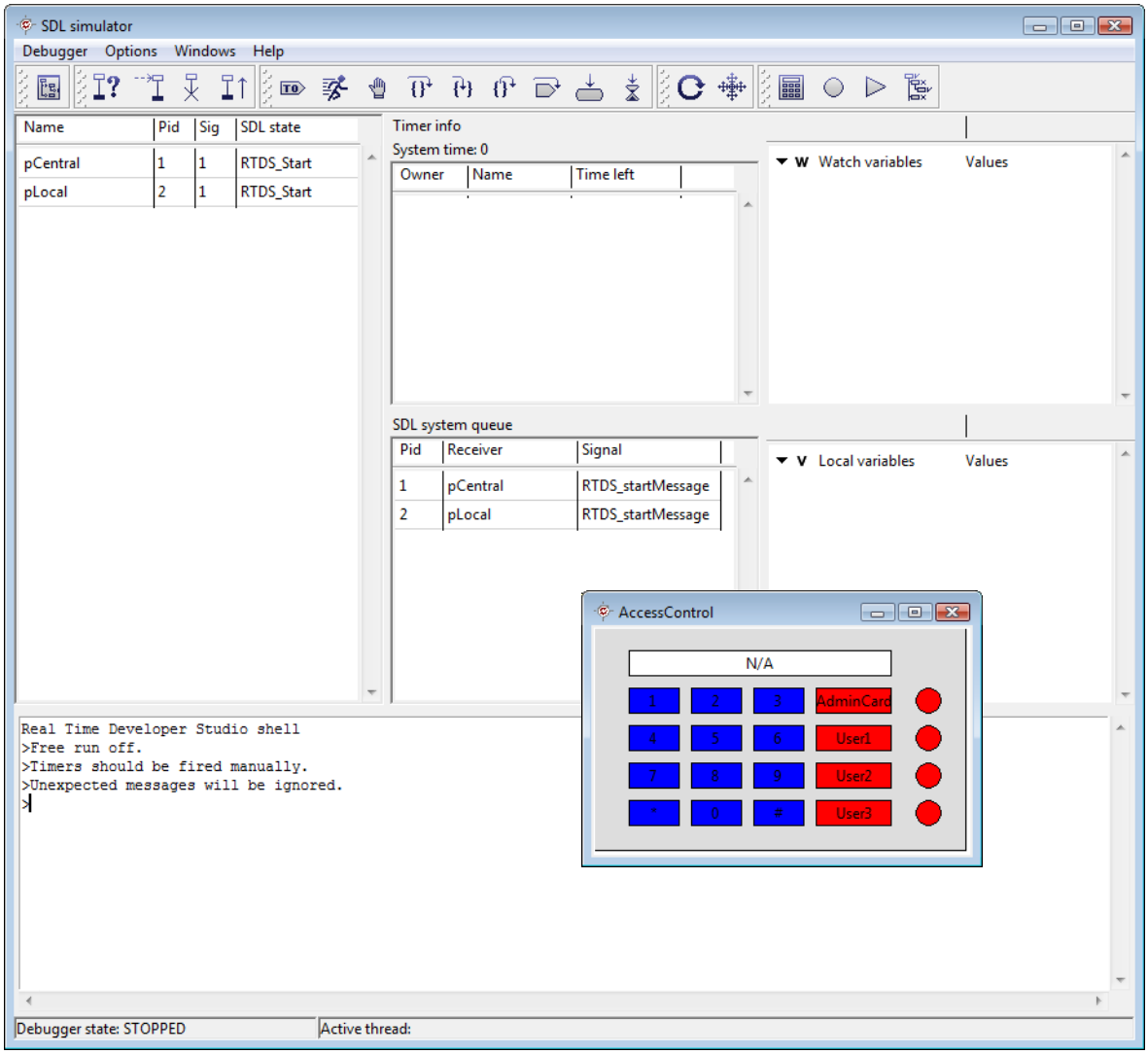
- `openDoor`
  Each door is a separate case with one filter. For the first door the filter `Door 1` will check if the first parameter is equal to 1. If the filter is verified, the color of the LED will switch to green. It is also possible to use the RVB form: `#00FF00`. In the `Door 2` case, the filter verifies the value is 2 and sets the second LED to green. And so on...
- `closeDoor`
  There is only one case with no filter. That means when the close message is received all the actions are executed. In our case, all the LEDs are set back to red.
- `displayMessage`
  There is no filter so the first parameter of the display message is printed in the display.

Each button generates an output. Let's consider three examples:

- `Key1`
  When this button is pressed, the `key` message is sent to the system with its first parameter set to 1
- `Key2`
  When this button is pressed, the `key` message is sent to the system with its first parameter set to 2
- `AdminCard`
  When this button is pressed, the `card` message is sent to the system with its first parameters set to `MasterCard`.

4.2 - Prototyping GUI runner

To start the prototyping GUI, click on in the Simulator or the Debugger:



The GUI will connect automatically to the running system. That's it.

5 - SDL-RT project

5.1 - Data and SDL types declarations

5.1.1 C types declarations

C types declaration can be made in several ways:

- in an external C header file that appears in the *Project manager*. The corresponding include will have to be done at block or process level in a text block,
- in an SDL text block; C code can be typed in directly. The C code covers different aspects depending on the SDL level it is found:
  - Block level
    The C code contained at block level will be generated as a C header that will be included in the underlying SDL architecture (blocks, process, and procedures). It can contain C types and C global variables declaration but not the global variables themselves. The global variables must be declared in separate C files included in the *Project manager*.
  - Process level
    The C code contained in text blocks in an SDL process will be inserted at the process function declaration level. It therefore contains local variables to the process.
  - Procedure level
    The C code contained in text blocks in an SDL procedure will be inserted at the procedure function declaration level. It therefore contains local variables to the procedure.

5.1.2 SDL messages and message lists declaration

SDL messages and message lists are declared either in a dashed text box in a diagram, or in a SDL-RT declarations file (`.rdm`) in packages. The declaration statements are:

```
MESSAGE <message name> [ ( <parameter type> {, <parameter type> }*
) ] ;
```

```
MESSAGE_LIST <list name> = <message name> { , <message name> }* ;
```

The parameter types in a `MESSAGE` declaration must be valid C types. Message lists may be nested by using `(<list name>)` in the list elements declaration.

Example:

```
MESSAGE msg1, msg2(int), msg3(char*, struct MyType*, double);
MESSAGE_LIST myList = msg1, msg2, msg3;
MESSAGE_LIST mySuperList = (subList1), (subList2), addlMsg;
```

5.1.3 SDL timer declaration

SDL timers do not need any declaration. The code generator will browse the whole system and extract the used timers automatically.

5.1.4 Semaphore declaration

Semaphores need to be declared with the semaphore declaration symbol. The syntax in this symbol is:

```
<semaphore type> <semaphore name> (<option 1>, [<option 2>] [,<option 3>])
```

`<semaphore type>` can be:

- BINARY
  <option 1> is:
  - PRIO
  - FIFO

  <option 2> is:
  - INITIAL_EMPTY
  - INITIAL_FULL
- MUTEX
  <option 1> is:
  - PRIO
    Queue pended tasks on the basis of their priority
  - FIFO
    Queue pended tasks on a first-in-first-out basis

  <option 2> is:
  - DELETE_SAFE
    Protect a task that owns the semaphore from unexpected deletion

  <option 3> is:
  - INVERSION_SAFE
    Protect the system from priority inversion
- COUNTING
  <option 1> is:
  - PRIO
  - FIFO

  <option 2> is:
  - <value for initial count (int)>

Example:

```
MUTEX mySemaphore(FIFO, DELETE_SAFE)
```

This example creates a mutual exclusion semaphore called mySemaphore with tasks pending on a first-in-first-out basis with protection from unexpected deletion of the owning task. Option 3 is omitted so the system is not protected against priority inversion.

5.1.5 Process declaration

A process is declared graphically in an SDL block diagram. The code generator will then generate the C function corresponding to the behavior description made in SDL.

The syntax is the following:

```
<process name> [(<initial number of instances, maximum number of
instances>)] [:<process type>] [PRIO <priority>]
```

to create <initial number of instances> instance of <process type> named <process name> with priority <priority> at startup.

The default priority is defined by RTDS_DEFAULT_PROCESS_PRIORITY in RTDS_OS_basic.h. The default initial number of instance is 1. The maximum number of instances is just for documentation, no verification will be made at run time.

Examples:

```
myProcess
```

```
anotherProcess:aTypeOfProcess PRIO 80
```

```
aThirdProcess(0,10)
```

The last example is usually when the process is created by another process. They usually do not exist at startup.

5.1.6 Procedure declaration

A procedure is declared graphically with the procedure declaration symbol. The syntax is the syntax used to define a C function:

```
<return type> <function name> ({<parameter type> <parameter
name>}*);
```

Example:

```
int myFunction (short myParameter);
```

5.1.7 Class description

A class is described graphically with a class symbol in a class diagram. The syntax used is the UML syntax:

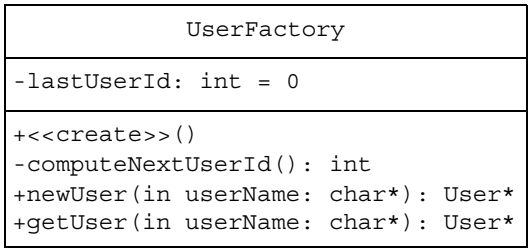
- The class header identifying the class itself is formatted like follows:
  `[<< <stereotype> >>] [<package name>::]<class name> [ {<properties>} ]`
  The two recognized stereotypes are <<interface>> and <<system>> (for active classes; see below). The properties may be specified, but are ignored.
- The attributes are described via a set of lines having the following format:
  `[<visibility>] <name> [: <type>] [= <default value>][ {properties} ]`
  The visibility may be '+' for public, '#' for protected and '-' for private. All basic C/C++ types are recognized. The default value and properties are ignored.
- The operations are described via a set of lines having the following format:
  `[<visibility>] <name>({<param>}*) [: <return type>] [ {properties} ]`
  where <param> has the format:
  `[<direction>] <name> [: <type>] [= <default value>]`
  The visibility is coded the same way than for attributes. Recognized types for parameters or return type are all C/C++ basic types, plus all classes known in the project. The direction for parameters may be "in" for input only parameters,

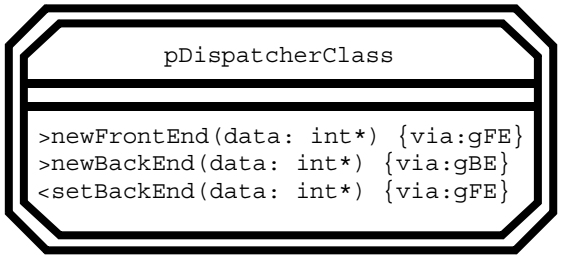
"out" for output-only parameters, or "inout" for two-way parameters. The operation properties are ignored.
Note: parameters declared as "out" and "inout" are both passed as references to the method (<type>&).

Class constructor(s) and destructor are identified via the special names <<create>> and <<delete>> respectively. As in C++, there may be several constructors with different parameters, but only one destructor. There must be no return type for any constructor or destructor.

Systems, blocks, processes, block classes and process classes may also be referenced in class diagrams. In this case, they are represented as active classes, as explained in SDL-RT specification. These active classes may not have attributes, which are meaningless in this case. They may however have operations, representing incoming and outgoing signals for the object. These operations are indicated by special visibilities '>' for incoming signals and '<' for outgoing ones. These pseudo-operations may only accept one in parameter which is the data associated to the signal. For block and process classes, the properties are used to indicate via which gate goes the signal ({via:<gate name>}).

Examples:





5.2 - SDL-RT symbols syntax

5.2.1 Task block

The task block contains standard ANSI C code as it would be written in a text file.

Example

```
/* Say hi to your friend */
printf("Hello world !\n");
for (i=0;i<MAX;i++)
   {
```

5.2.2 Next state

The syntax in the next state SDL graphical symbol is:

<new SDL state>

Of course, the new SDL state needs to be defined in the diagram.

Or it can also be:

```
"-"
```

meaning the state is not changed.

5.2.3 Continuous signals

The continuous signal can contain any standard C expression that returns a C true/false expression. In the generated code the expression is put in an `if` statement as is. Since an SDL state can contain several continuous signal a priority level needs to be defined with the `PRIO` keyword. Lower values correspond to higher priorities. The syntax is:

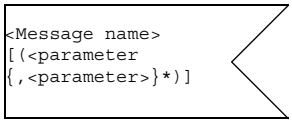
```
<C condition expression>
PRIO <priority level>
```

Example:

```
( a>5 )
PRIO 3
```

5.2.4 Message input

The message input symbol represent the type of message that is expected in an SDL-RT state. It always follows an SDL-RT state symbol and if received the symbols following the input are executed.

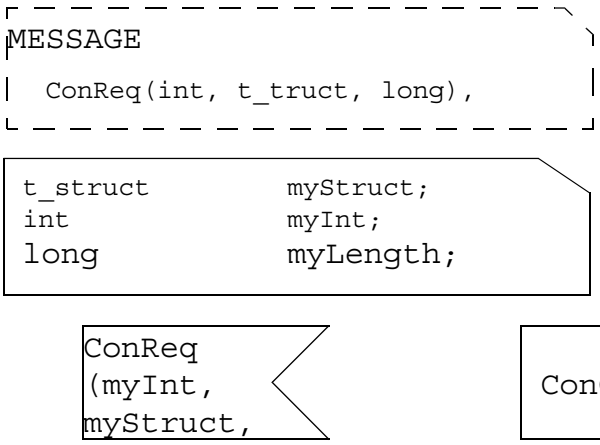


An input has a name and comes with optional parameters. To receive the parameters it is necessary to declare a variable for each expected parameter. The syntax in the message input symbol is the following:

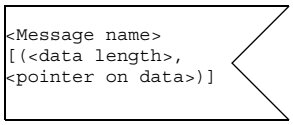
```
<Message name> [(<parameter name> {, <parameter name>}*)]
```

`<parameter name>` are variables that need to be declared.

Examples:



myInt, myStruct, and myLength will be assigned to the value of the received mes-



Even though it is not recommended, if a message is declared without any parameter it is possible to transmit undefined parameters with a length and a pointer on the parameter data. In that case it is necessary to declare 2 variables that will be the parameter length and the pointer on the parameters.

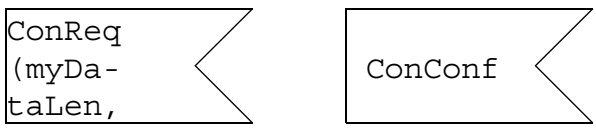
The syntax in the message input symbol is the following:

<Message name> [(<length of data>, <pointer on data>)]

<data length> is a variable that needs to be declared.

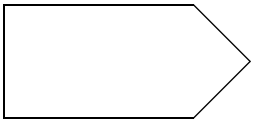
<pointer on data> needs to be declared.

Examples:



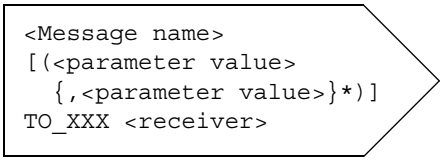
5.2.5 Message output

5.2.5.1 General aspects



The syntax in the message output symbol can be written in 3 ways depending on whether the queue Id of the receiver is known or not, and if its name is constant or variable. A message can be sent to a queue Id, a process name or via a channel or gate. When communicating with the environment, a special syntax is provided.

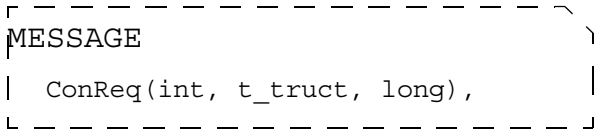
Messages can have parameters. The type of the parameters are defined in the message declaration.

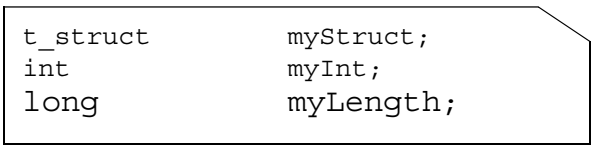


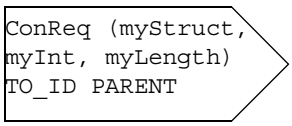

```
<message name>[(<parameter value> {,<parameter value>}*] TO_XXX
<receiver>
```

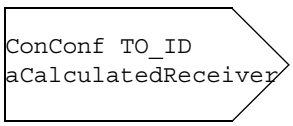
`<parameter value>` is the value of the parameter with the type declared in the message declaration. The parameters can be transmitted as values or references. When the parameters are direct values, the data is first copied and then sent out. When the parameters are references, the receiver and the sender end up with the same reference on the data. Is it then very important to define which process owns the data in order to avoid data corruption. It is usual to consider the sender does not own the data any more once it has been sent, and it is the receiver's responsability to free the associated memory if needed.

Examples

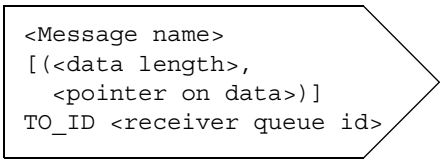








Even though it is not recommended, it is also possible to use a generic parameter assignment when there is no parameter type declaration:

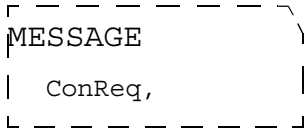


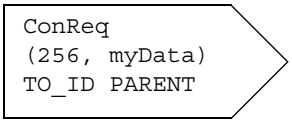
`<message name> [(<length of data>,<pointer on data>)] TO_ID <receiver queue id>`

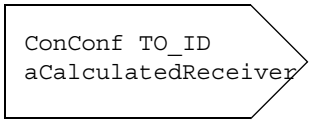
`<receiver queue id>` is of type `RTDS_QueueId`

The generated code will copy the data of size `<length of data>` pointed by `<pointer on data>`.

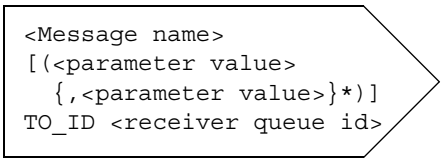
Examples







5.2.5.2 Queue Id

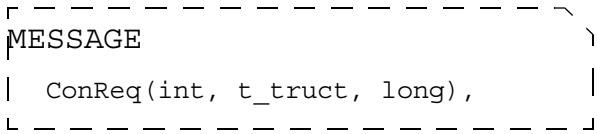


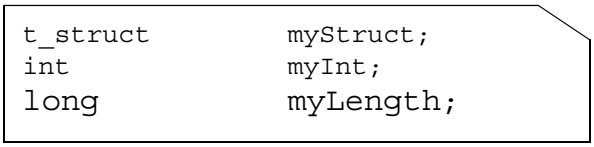
`<message name>[(<parameter value> {,<parameter value>}*] TO_ID <receiver queue id>`

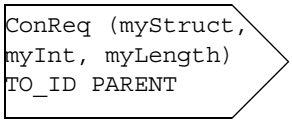
- `<parameter value>` is the value of the parameter with the type declared in the message declaration,
- `<receiver queue id>` is of type `RTDS_QueueId`.
  It can take the value given by the SDL keywords:

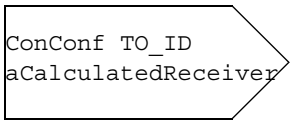
`PARENT`	The queue id of the parent process.
`SELF`	The queue id of the current process.
`OFFSPRING`	The queue id of the last created process if any or NULL if none.
`SENDER`	The queue id of the sender of the last received message.

Examples

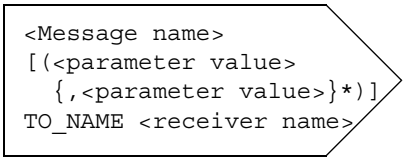








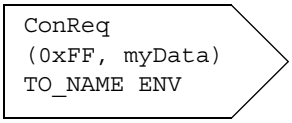
5.2.5.3 Process name

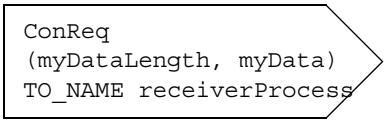



```
<message name> [(<parameter value> {,<parameter value>}*] TO_NAME <receiver name>
```

`<receiver name>` is the name of a process if unique or it can be `ENV` when simulating and the message is sent out of the SDL system.

Example

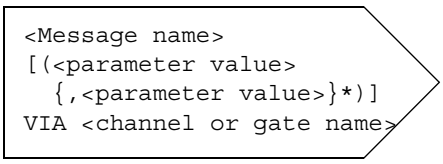




Note:

If several instances have the same process name (several instances of the same process for example), the 'TO_NAME' will send the message to the first created process with the corresponding name. Therefore this method should no be used when the process name is not unique within the system.

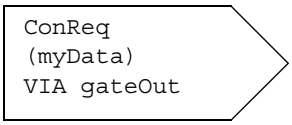
5.2.5.4 Via a channel or gate

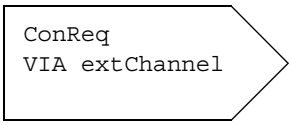



```
<message name> [(<parameter value> {,<parameter value>}*] VIA <channel or gate name>
```

`<channel or gate name>` is the name channel or gate connected to the current process or process class.

Example

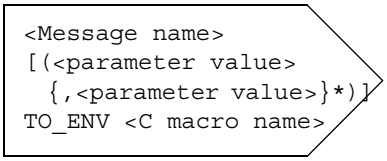




Note:

The actual receiver is resolved statically. So there must be no ambiguity in the channels allowing the signal to pass. Also note that a VIA is resolved to a process name, so the note in paragraph 5.2.5.3 applies.

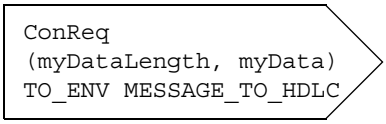
5.2.5.5 Environment




```
<message name> [(<parameter value> {,<parameter value>}*] TO_ENV <C macro name>
```

`<C macro name>` is the name of the macro that will be called when this SDL output symbol is hit. If no macro is declared the message will be sent to the environment process; that obviously only works when simulating but not for the final code.

Example



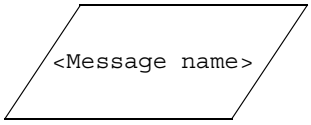
In this second example the generated code will be:

```
MESSAGE_TO_HDLC(ConReq,myDa-
```

Note:

When sending data pointed by <pointer on data>, the corresponding memory should be allocated by the sender and should be freed by the receiving process. This is because this memory area is not copied to the receiver; only the pointer value is transmitted. So after being sent the sender should not use it any more.

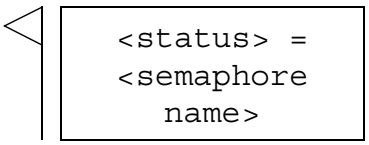
5.2.6 Saved message



The syntax to save an SDL message in the save graphical symbol is:

```
<message name>
```

5.2.7 Semaphore take



To take a semaphore, the syntax in the 'semaphore take SDL-RT graphical symbol' is:

`<status> = <semaphore name> (<timeout option>)`

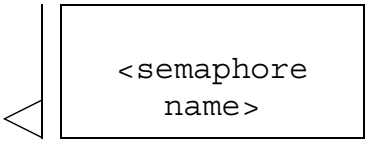
where `<timeout option>` is:

- `FOREVER`
  Hangs on the semaphore forever if not available.
- `NO_WAIT`
  Does not hang on the semaphore at all if not available.
- `<number of ticks to wait for>`
  Hangs on the semaphore the specified number of ticks if not available.

and `<status>` is of type `RTDS_SemaphoreStatus` and can take the following values:

- `RTDS_OK`
  If the semaphore has been successfully taken
- `RTDS_ERROR`
  If the semaphore was not found or if the take attempt timed out.

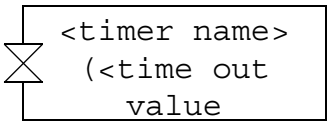
5.2.8 Semaphore give



To give a semaphore, the syntax in the 'semaphore give SDL-RT graphical symbol' is:

`<semaphore name>`

5.2.9 Timer start

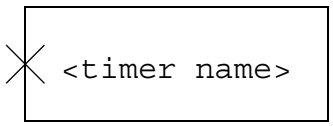


To start a timer the syntax in the 'start timer SDL-RT graphical symbol' is :

`<timer name> (<time value in tick counts>)`

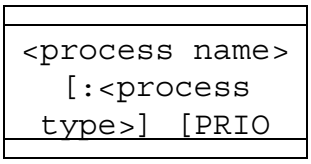
`<time value in tick counts>` is usually an 'int' but is RTOS and target dependant.

5.2.10 Timer stop



To cancel a timer the syntax in the ‘cancel timer SDL-RT graphical symbol’ is : `<timer name>`

5.2.11 Process



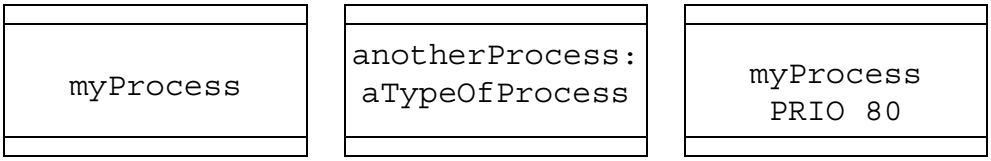
To create a process the syntax in the ‘create process SDL-RT graphical symbol’ is:

`<process name>[:<process type>] [PRIO <priority>]`

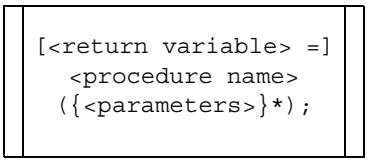
to create one instance of `<process type>` named `<process name>` with priority `<priority>`.

The default priority will be 150.

Examples



5.2.11.1 Procedure call

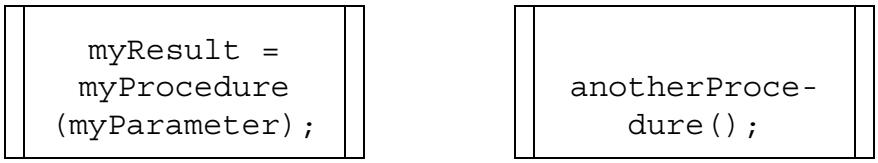


The procedure call symbol is used to call an SDL-RT procedure (Cf. “Procedure declaration” on page 117). Since it is possible to call any C function in an SDL-RT task block it is important to note SDL-RT procedures are different because they know the calling process context, e.g. SDL-RT keywords such as SENDER, OFFSPRING, PARENT are the ones of the calling process.

The syntax in the procedure call SDL graphical symbol is the standard C syntax:

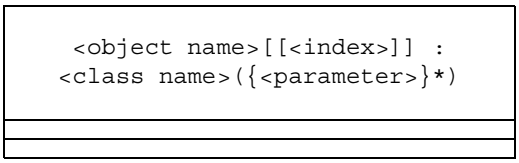
`[<return variable> =] <procedure name>({<parameters>}*);`

Examples

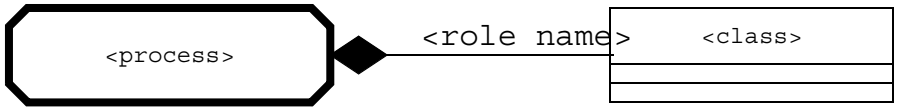


Note: A procedure defined in SDL can not be called directly from a C statement. It has to be called from the procedure call graphical symbol. This is due to the fact that the procedure needs to know the process context so the generated code adds a parameter to the procedure definition and call.

5.2.12 Object initialization



The object initialization symbol is used when a class is attached to a process or process class via a composition link. This composition is made in a class diagram like follows:

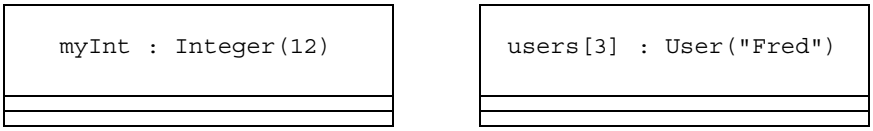


In this case, one or several instances of `<class>` are part of the process `<process>`, depending on the composition's cardinality. These instances are known in the process via a variable named `<role name>`.

The object initialization symbol may be used like follows:

- If the maximum number of instances is 1, the object initialization symbol *must* be used to initialize the object in the start transition for the process. No `[<index>]` must follow the object name in the symbol.
- If the maximum number of instances is more than one, it is possible but not mandatory to use the object initialization symbol to initialize one of the objects in the list of associated instances. In this case, an `[<index>]` must be specified.

Examples



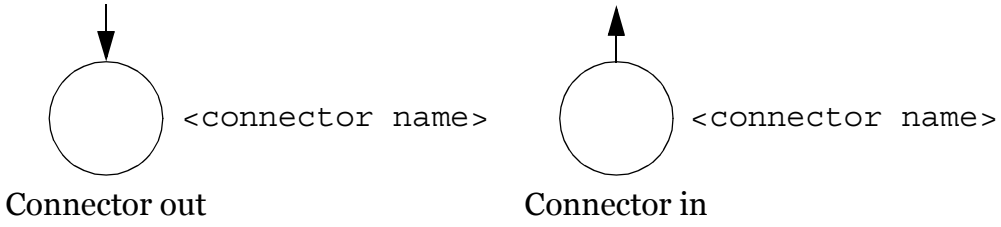
Note

In the generated code, using a task block containing:

```
<object> = <class>(<parameters...>);
```

is exactly the same than using the object initialization symbol, except for the added semantics checking in the case of compositions with a maximum cardinality of 1.

5.2.13 Connectors



Connectors are used to:

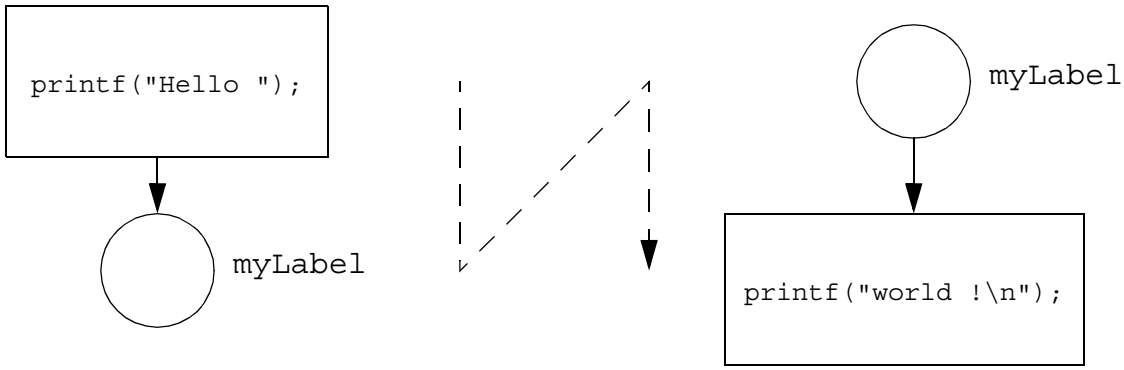
- split a transition into several pieces so that the diagram stays legible and printable,
- to gather different branches to a same point.

A connector-out symbol has a name that relates to a connector-in. The flow of execution goes from the connector out to the connector in symbol.

A connector contains a name that has to be unique in the process. The syntax is:

```
<connector name>
```

Examples



5.2.14 Decision

The expression to evaluate in the symbol can contain:

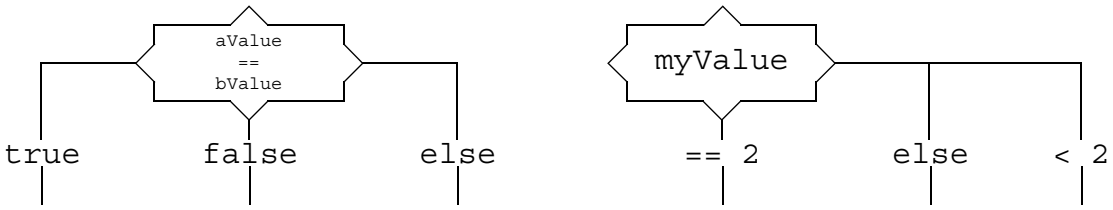
- any standard C expression that returns a C true/false expression,
- an expression that will be evaluated against the values in the decision branches.

The values of the branches have keyword expressions such as:

- `>, <, >=, <=, !=, ==`
- `true, false, else`

The `else` branch contains the default branch if no other branch made it.

Examples



5.2.15 SDL keywords

5.2.15.1 Global keywords

The following SDL keywords are defined and can be used in all SDL symbols:

`PARENT` The queue id of the parent process.

`SELF` The queue id of the current process.

`OFFSPRING` The queue id of the last created process if any or NULL if none.

`SENDER` The queue id of the sender of the last received message.

5.2.15.2 Local keywords

The following keywords are dedicated to specific SDL symbols :

keywords	concerned symbols
`PRIO`	Task definition Task creation Continuous signal

`TO_NAME`
`TO_ID`
`ENV`
	Message output

`FOREVER` `NO_WAIT`	semaphore manipulation

`BINARY`
`MUTEX`
`COUNTING`
`PRIO`
`FIFO`
`INITIAL_EMPTY`
`INITIAL_FULL`
`DELETE_SAFE`
`INVERSION_SAFE`
	semaphore declaration

Table 1: Keywords in symbols

keywords	concerned symbols
`>, <, >=, <=, !=, == true, false, else`	decision branches
`USE SDL_MESSAGE_LIST`	text symbol

Table 1: Keywords in symbols

5.3 - Code generation

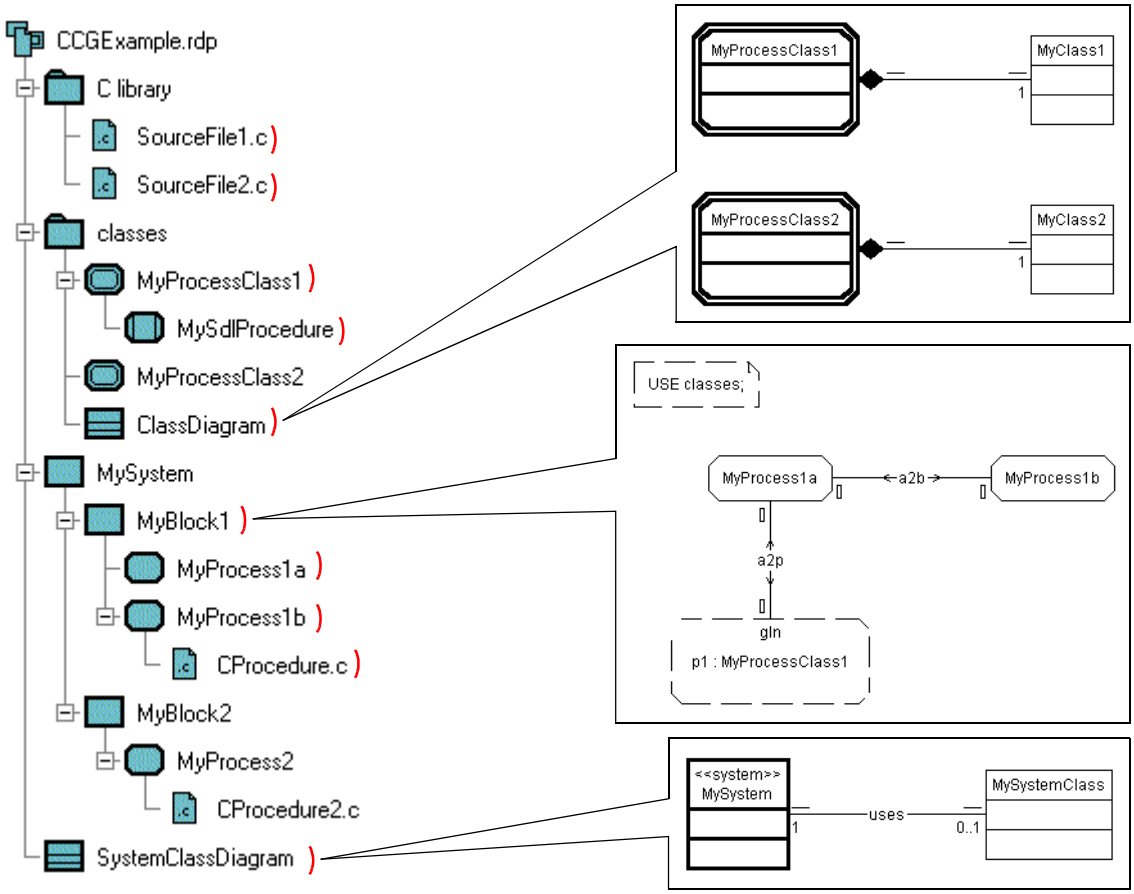
The code generation for an agent is run from the project manager by selecting the agent, then choosing "Generate code..." in the "Generate" menu. Clicking on the button or selecting the "Build..." item in the "Generate" menu also generate the code, but also runs the whole build process if enabled in the generation options (see “Profiles” on page 133).

5.3.1 Concerned elements

The elements concerned by the code generation are the following:

- All elements in the agent sub-tree, including SDL diagrams and C/C++ source files;
- All agent classes used in any diagram of the agent sub-tree, with the sub-tree for the agent class;
- All C/C++ source files that do not appear as children of SDL diagrams;
- All classes linked by any association to any involved agent or one of its parents, and all associated classes recursively.

For example, if the project tree is:



If we generate the code for the block "MyBlock1", the included elements are in the diagrams marked in red:

- The block "MyBlock1";

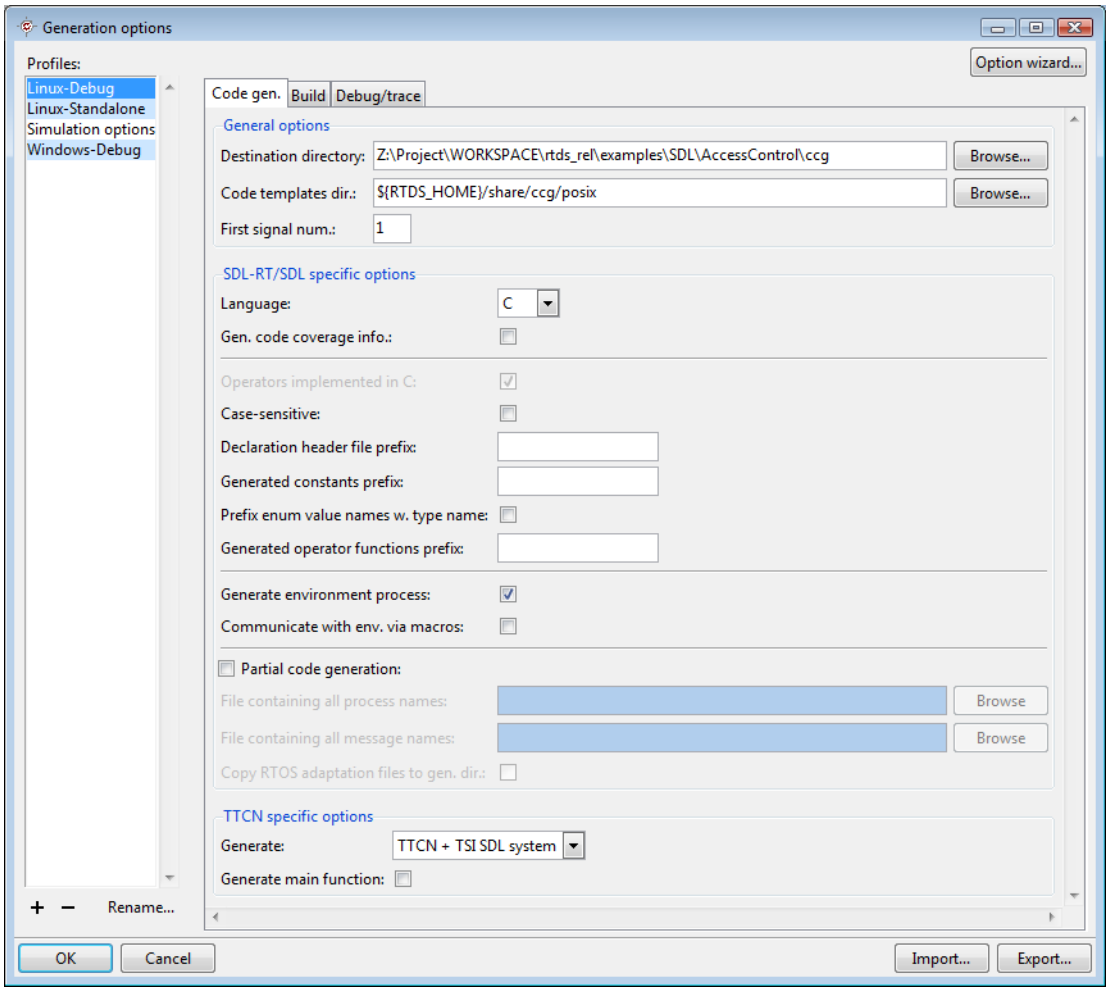
- The processes "MyProcess1a" and "MyProcess1b", and the C source file "CProcedure1.c", since they are in the block's sub-tree;
- The process class"MyProcessClass1", since the block contains an instance of the class;
- The procedure "MySDLProcedure" since it's in the sub-tree for the process class;
- The C source files "SourceFile1.c" and "SourceFile2.c" since they're not children of any SDL diagrams;
- The class MyClass1, since it is linked to MyProcessClass1 in diagram "ClassDiagram";
- The class MySystemClass, since it is linked to MySystem in diagram "SystemClassDiagram" and MySystem is a parent of MyBlock1.

The process class "MyProcessClass2" is not included since no instance of this class appears in "MyBlock1" or any of its descendants. The C source file "CProcedure2.c" is not included since it's in a sub-tree of an SDL diagram, but not the generated one. The class "MyClass2" is not included since it is only linked to the process class "MyProcessClass2", which is not involved in the code generation.

5.3.2 Profiles

5.3.2.1 Description

The options concerning the code generation and compilation are managed via a set of profiles stored with the project. These profiles are displayed via the item "Options..." in the "Generate" menu of the project manager.



Code generation profiles

The left part of the dialog displays the names of the existing profiles. It also allows to add, delete or rename profiles via the "+", "-" and "Rename..." buttons respectively. Adding a profile also allows to copy the selected one in the list. Selecting a profile name in the list displays the options set for this profile in the right part.

The "Option wizard..." button on the top of the dialog allows to quickly create a typical working profile depending on the platform, RTOS, and debugger. It is described in paragraph “Option wizard” on page 137.

The buttons "Import profile..." and "Export profile..." at the bottom right of the dialog allow to export a generation profile in a file, and then to import it back in another project.

The following paragraphs describe the options in the dialog tabs.

5.3.2.1.1 Code generation options

This tab is displayed above (paragraph “Description” on page 133). The options are:

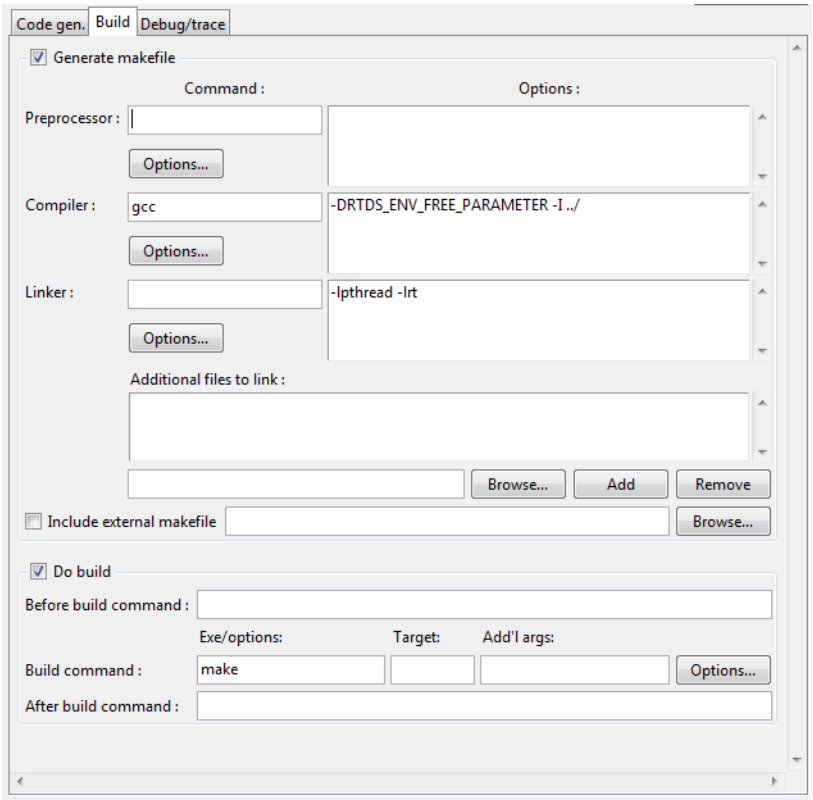
- *General options* group:
  - *Destination directory* is the directory where all files will be generated.
  - *Code templates directory* is the directory containing the files used to generate the code.
  - *First signal num.* is the lowest number to use for signal numerical values. This option is useful if your system includes processes defined outside RTDS that use signal numerical values of their own. Setting this option to a value higher than any existing signal numerical value will ensure that RTDS never generates an already used one.
- *SDL-RT / SDL specific* group:
  - *Language* is the programming language used for the export. It can be C or C++.
  - If the *Gen. code coverage info.* check box is checked, the code to extract code coverage will be generated in addition to the normal code. See paragraph “Code coverage” on page 211.
  - The *Operators implemented in C* option is only meaningful if the generation language is C++ and the project language is SDL. It indicates that the functions implementing the SDL operators are C functions and that their declaration should be generated in an `extern "C"` block.
  - If the *Case-sensitive* option is checked, the code generation will be made in case-sensitive mode. This option is only meaningful if the project language is SDL. The default is to use for each identifier the case for the first time it is seen in the diagrams.
  - The *Declaration header file* prefix is added to the name of all generated declaration files.
  - The *Generated constants prefix* is added to all identifiers generated for SDL synonyms or literals. It has no effect in SDL-RT.
  - If the *Prefix enum values names w. type name* option is checked, the identifiers generated for SDL literals will be prefixed with the type name (in addition to the prefix above). This allows to have several types defining a literal with the same name. This option has no effect in SDL-RT.
  - The *Generated operator functions prefix* will be added to all declarations for the functions implementing the SDL operators. It has no effect in SDL-RT.
  - If the *Generate environment process* option is checked, a process simulating the environment will always be generated, even if none is present in the system.
  - If the *Communicate with environment with macros* option is checked, message output with the `TO_ENV` keyword followed by a macro name will always call the macro and not actually send a message. If the option is unchecked, an actual message sending is done, which requires an existing environment process. In this case, it is safer to check the previous option so that an environment process is always generated. If both options are unchecked and no explicit environment process exists in the system, code generation will fail.
  - Checking the *Partial code generation* checkbox allows to generate code allowing easier integration with an external scheduler. In this case, two files must be provided:

- One listing all the names of the RTDS processes that will be included in the final system, one name per line;
- One listing all the names of the messages that can be sent or received by all RTDS processes in the final system, one name per line.

These files are necessary to ensure the correct generation of files defining global information (e.g `RTDS_gen.h`).
If the *Copy RTOS adaptation files to gen. dir.* option is checked, all files in the profile directory used in the build will be copied to the generation directory, and the build process will use these files and not those in the RTDS installation directory. This allows to have a completely standalone generated code, which doesn't need a RTDS installation to be run.
Partial code generation is descibred in detail in paragraph "Integration in external scheduler" on page 183.

5.3.2.1.2 Build options

The tab for build options looks like follows:



The options are:

- If the *Generate makefile* check box is checked, a makefile will be generated. The following options set the commands and options that will be included in the makefile. The only mandatory command is the compiler. If the preprocessor is not set, there will be no explicit preprocessing phase; if the linker is not set, the compiler command will be used for linking.
- Use external makefile
  Some profiles such as Tornado, OSE, and CMX require a pre-defined external makefile. To include a user defined external makefile, the pre-defined include should be done in the new external makefile.

For profiles using GNU make (Cygwin, Gnu and Tornado), the external makefile can access environment variables via the regular makefile macro syntax (e.g. `${RTDS_HOME}`). Other flavors of make may also offer this possibility.

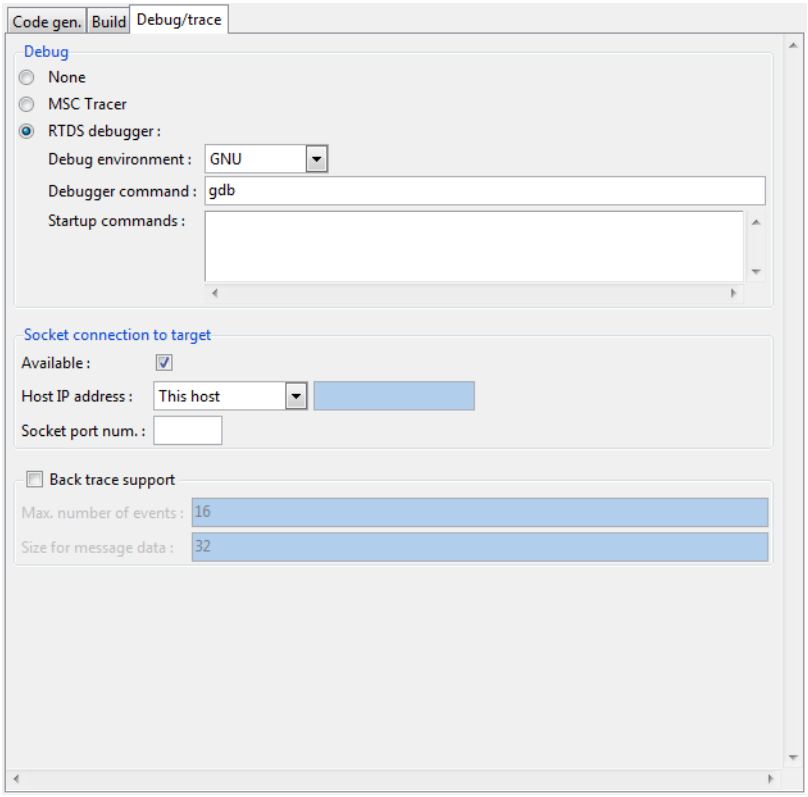
- If the *Do build* check box is set, the actual compilation will also be run by the code generation operation. The command run for the compilation itself is splitted in 3 parts:
  - The executable name with the options, e.g "`make`", or "`make -f MyMakefile`";
  - The target name, usually empty or "`RTDS_ALL`";
  - The additional arguments that should be passed after the target, e.g. makefile macro definitions ("`MACRO_NAME=value`").

  In addition to the compilation command, you may also enter two commands that will be run before and after the compilation respectively. In these command, the final executable name can be accessed with the following environment variables
  - `RTDS_TARGET_NAME` executable name with extension,
  - `RTDS_TARGET_BASE_NAME` executable name without extension.

  Please note the syntax to access environment variables depending on the host platform:
  - DOS: `%RTDS_TARGET_NAME%`
  - Unix: `$RTDS_TARGET_NAME`

5.3.2.1.3 Debug and trace options

The tab for debug and trace options looks like follows:



The *Debug* group defines the debug environment to use.

- If set to *None*, the profile is considered to be for generating the final code, meaning it will:

- use the options in the `common` section of the `DefaultOptions.ini` file in the Code templates directory (Cf. Reference manual),
- not start any debugger.

- If set to *MSC Tracer*, the profile is also for generating the final code, but the generated executable will be able to trace all its actions using PragmaDev MSC Tracer.
- If set to *RTDS Debugger*, the profile is a debug profile, meaning it will:
  - use the options in the `common` and `debug` section of the `DefaultOptions.ini` file in the Code templates directory (Cf. Reference manual),
  - start the C debugger and the corresponding SDL-RT debugger interface. The command for the debugger is set in the corresponding field. The field *Startup commands* contains commands to be sent to the debugger once it is started.

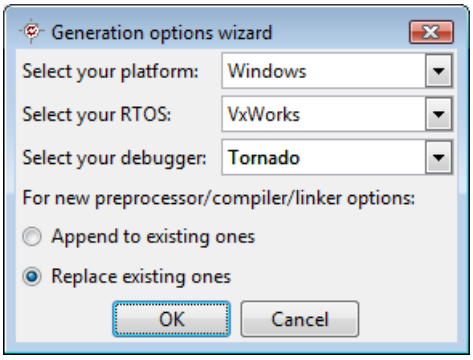
The options in the "*Socket connection to target*" group configure the host to target communication. They are used by the target program to send trace information:

- to RTDS's graphical debugger during a debug session;
- to PragmaDev MSC Tracer if its support has been activated.

The value for the "*Host IP address*" option can be "*This host*", meaning the machine where RTDS is currently running, "*Target host*", meaning the machine where the target will run, or "*Forced host*" to specify a user-defined IP address.

5.3.2.2 Option wizard

Almost all of the options described in paragraph “Description” on page 133 may be automatically set by using the "Option wizard..." button at the top of the generation profile dialog. Pressing this button will display the following dialog:



The dialog allows to modify the currently displayed profile to work with a standard environment provided with RTDS, identified by the platform it runs on, the RTOS and the debugger used if needed. If the updated profile already has any field set, it's better to choose the "Append to existing ones" option.

Validating the dialog will then automatically set the following fields:

- *Code templates directory*,
- Preprocessor, compiler, linker commands and options,
- For some RTOSs, *Additional files to link* and/or *Include external makefile*,
- *Compilation command*,
- For some RTOSs, *Before compil. command* and/or *After compil. command*,
- *Debug* environment, plus *Debugger command* if environment is not *None*.

The check-boxes *Generate makefile* and *Do compilation* are also automatically checked.

5.3.2.3 VxWorks profile

Real Timer Developer Studio includes a *Code template directory* to generate *VxWorks* applications and the SDL-RT debugger is interfaced with *Tornado* providing a consistent environment.

The profile characteristics are:

- Timer values are set in number of system ticks,
- The SDL-RT process priorities are the ones of VxWorks. The default value is 150.

To generate *VxWorks* application, it is recommended to use *Wind River* special `make` utility and define the `CPU`. The corresponding makefile will be automatically generated and compiled with the right options. Classical CPU definitions are:

- SIMNT
  When generating applications to be executed on VxSim on Windows
- SIMSPARCSOLARIS
  When generating applications to be executed on VxSim on Solaris
- PENTIUM
  When generating applications to be executed on a Pentium target
- PPC860
  When generating applications to be executed on a PowerPC 860 target
- ...

The compiler command, the linker command, and the compiler options should be set to use the ones from Wind River:

- compiler command: $(CC)
- compiler options: $(CFLAGS)
- linker command: $(LD_PARTIAL)

The Tornado debugger command is different for each target. Classical debugger commands are:

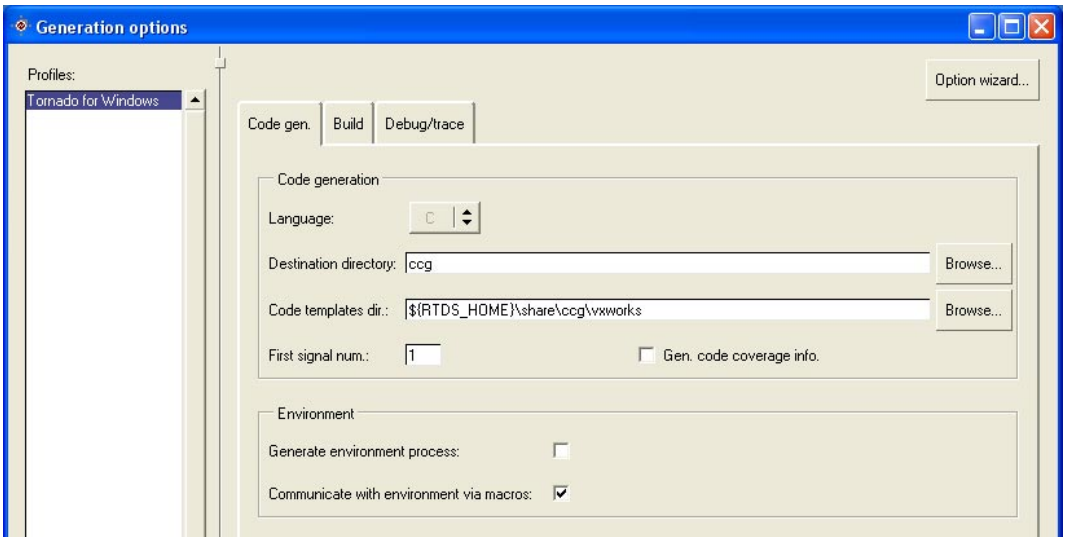
- gdbsimnt
  When debugging on Windows host with VxSim
- gdbsimso
  When debugging on Solaris host with VxSim
- gdbi86
  When debugging on Pentium based targets whatever the communication link is (serial or ethernet)
- gdbppc
  When debugging on PowerPC based targets whatever the communication link is (serial or ethernet)
- ...

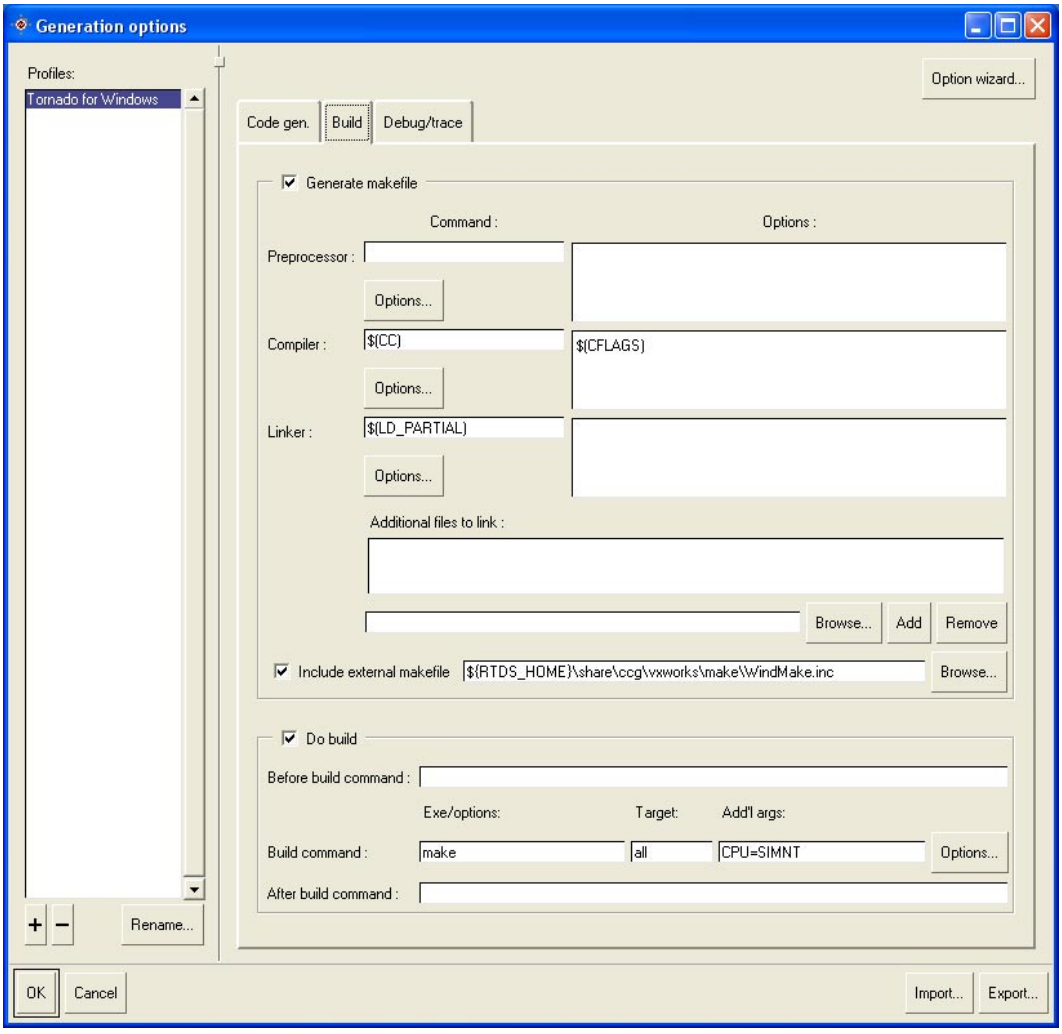
Note the generated makefile requires to include a *Wind River* specific part:

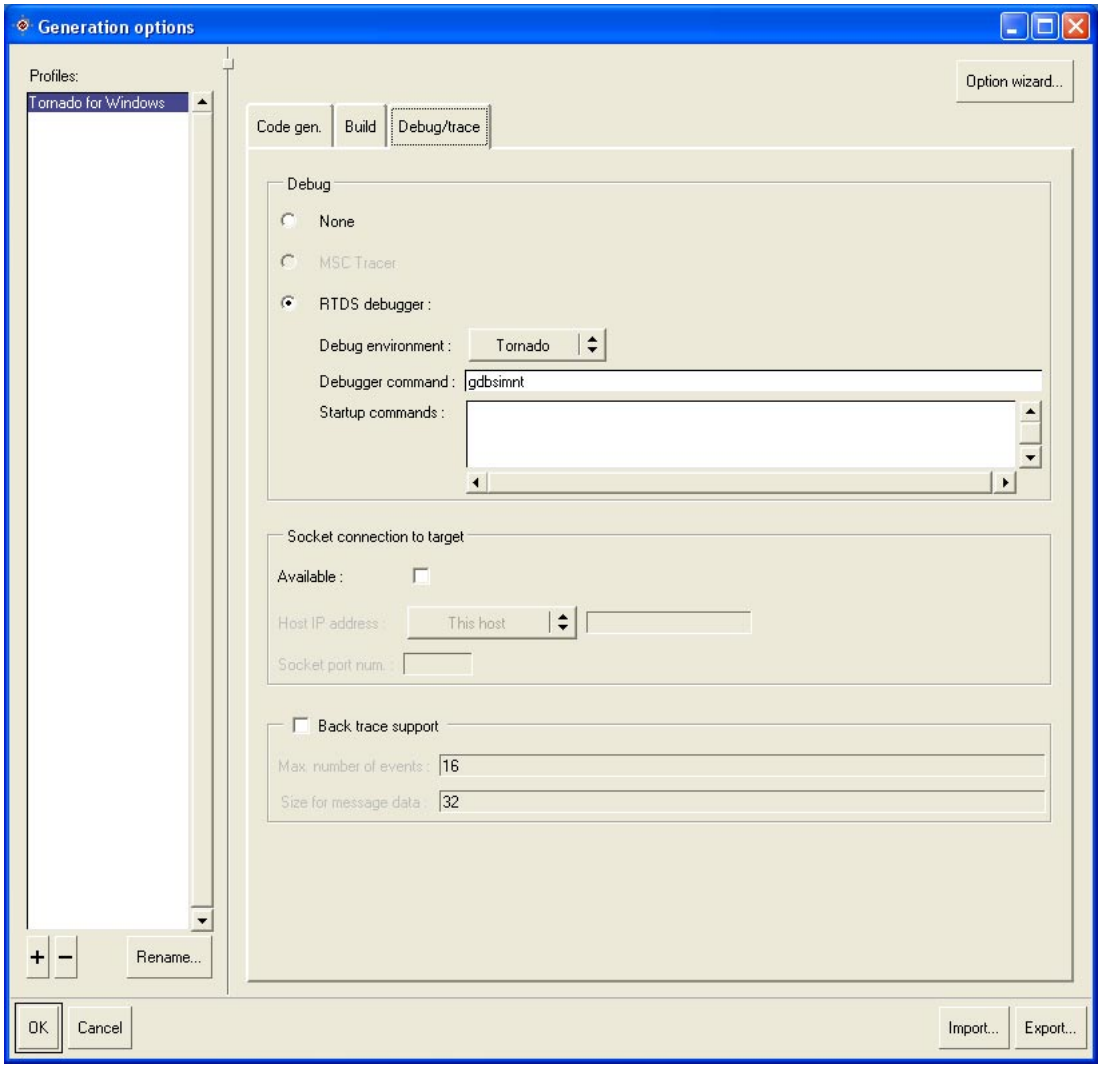
```
include C:\RTDS\share\ccg\vxworks\make\WindMake.inc
```

to be interpreted and expanded by *Wind River* make utility.

On Windows:

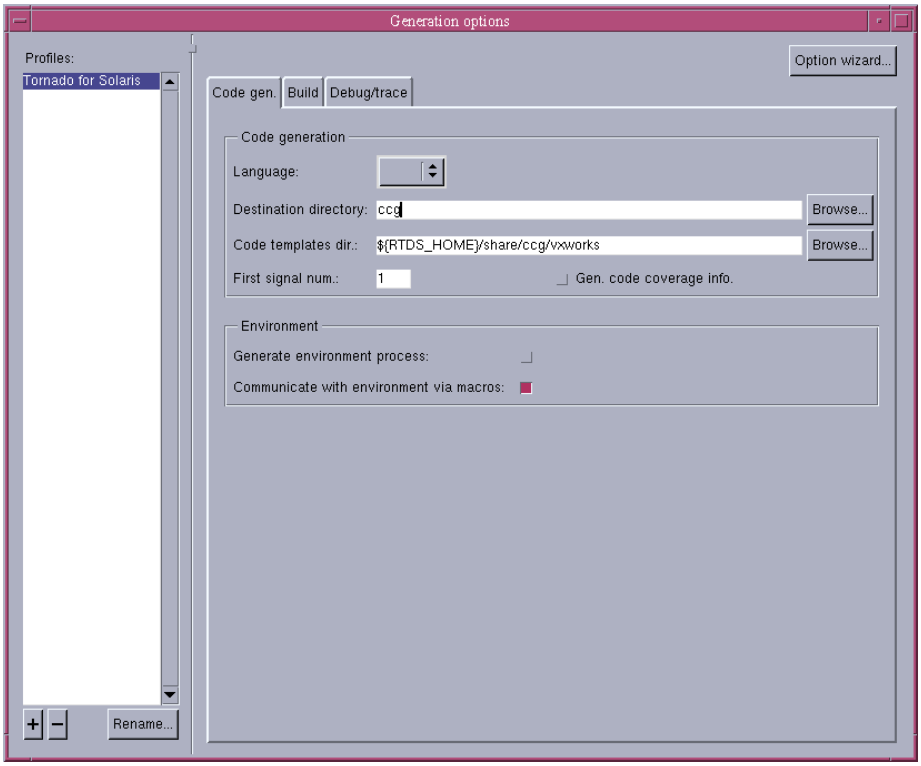

Generation options
Profiles:
Tornado for Windows
Option wizard...
Code gen.
Build
Debug/trace
Code generation
Language:
C
Destination directory:
ccg
Browse...
Code templates dir.:
${RTDS_HOME}\share\ccg\vxworks
Browse...
First signal num.:
1
Gen. code coverage info.
Environment
Generate environment process:
Communicate with environment via macros:

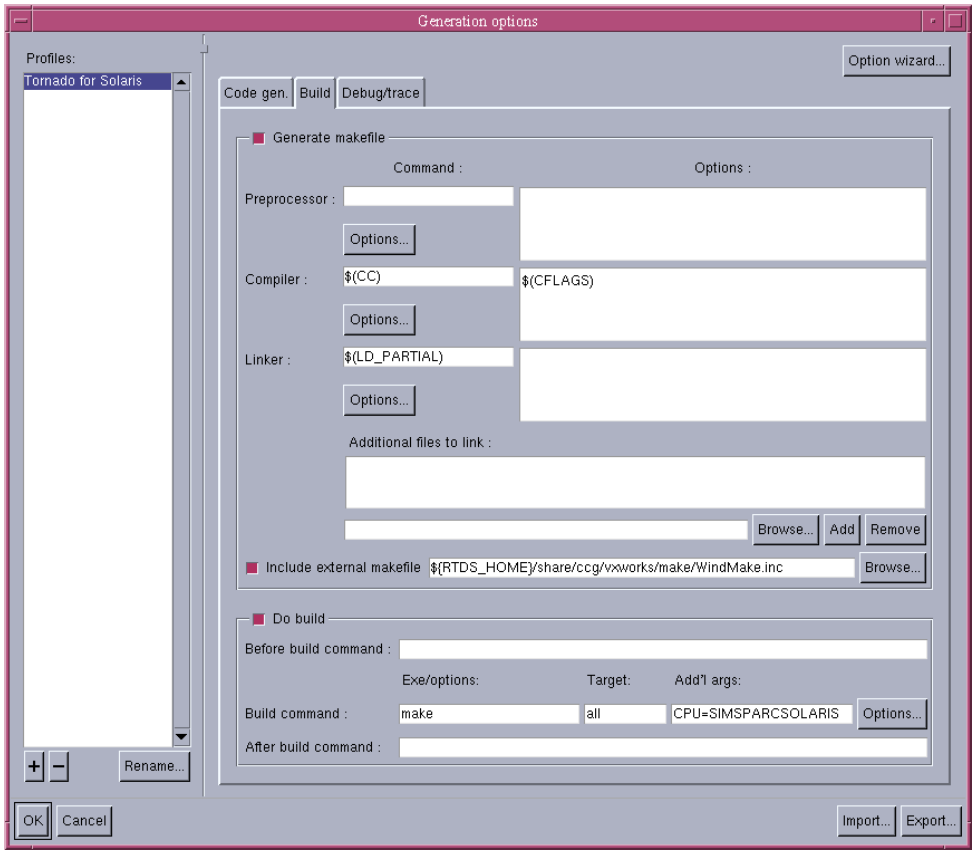

Generation options
Profiles:
Tornado for Windows
Option wizard...
Code gen.
Build
Debug/trace
Generate makefile
Command :
Options :
Preprocessor :
Options...
Compiler :
$(CC)
$(CFLAGS)
Options...
Linker :
$(LD_PARTIAL)
Options...
Additional files to link :
Browse...
Add
Remove
Include external makefile
${RTDS_HOME}\share\ccg\vxworks\make\WindMake.inc
Browse...
Do build
Before build command :
Exe/options:
Target:
Add'l args:
Build command :
make
all
CPU=SIMNT
Options...
After build command :
Rename...
OK
Cancel
Import...
Export...

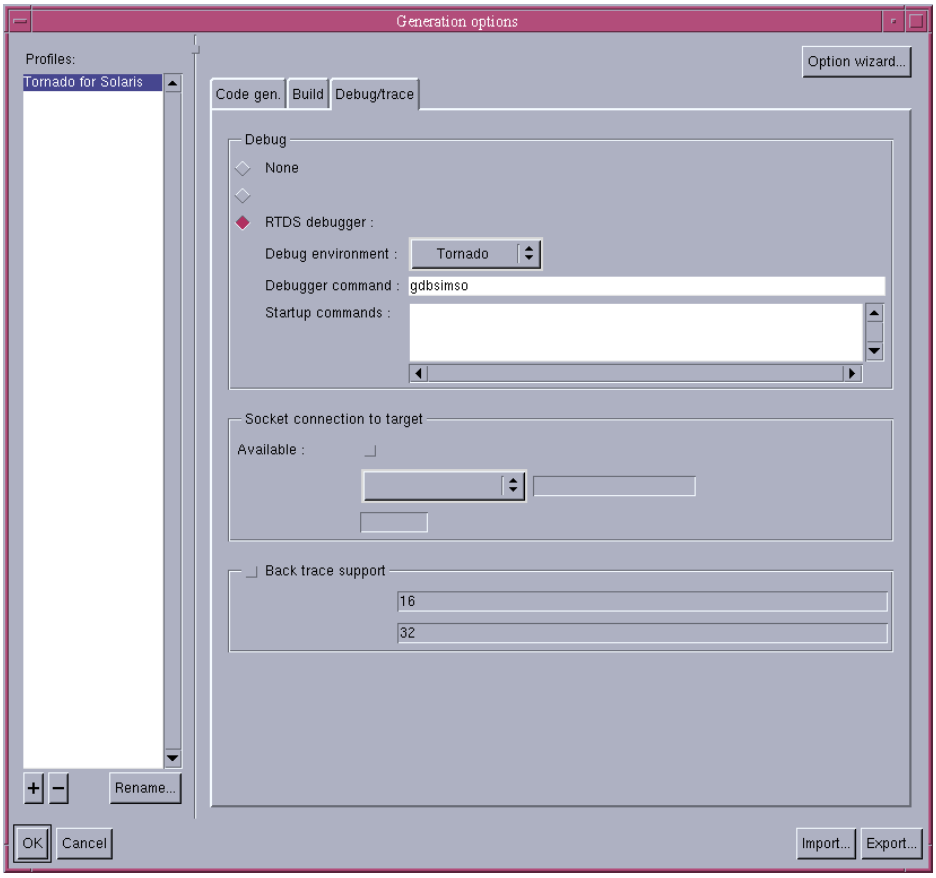


Typical generation profile to debug with VxSim on Windows

On Solaris:


Generation options
Profiles:
Tornado for Solaris
Option wizard...
Code gen.
Build
Debug/trace
Code generation
Language:
Destination directory:
ccg
Browse...
Code templates dir.:
${RTDS_HOME}/share/ccg/vxworks
Browse...
First signal num.:
1
Gen. code coverage info.
Environment
Generate environment process:
Communicate with environment via macros:
Rename...


Generation options
Profiles:
Tornado for Solaris
Option wizard...
Code gen.
Build
Debug/trace
Generate makefile
Command :
Options :
Preprocessor :
Options...
Compiler :
$(CC)
$(CFLAGS)
Options...
Linker :
$(LD_PARTIAL)
Options...
Additional files to link :
Browse...
Add
Remove
Include external makefile
${RTDS_HOME}/share/ccg/vxworks/make/WindMake.inc
Browse...
Do build
Before build command :
Exe/options:
Target:
Add'l args:
Build command :
make
all
CPU=SIMSPARCSOLARIS
Options...
After build command :
Rename...
OK
Cancel
Import...
Export...



Typical generation profile to debug with VxSim on Solaris

5.3.2.4 CMX RTX profile

Real Timer Developer Studio includes a *Code template directory* to generate *CMX* applications and the SDL-RT debugger is interfaced with *Tasking Cross View Pro* providing a consistent environment. In the current release the *Tasking* debugging profile requires the application to run on *CMX* RTOS and that integration is only available on Windows.

The profile characteristics are:

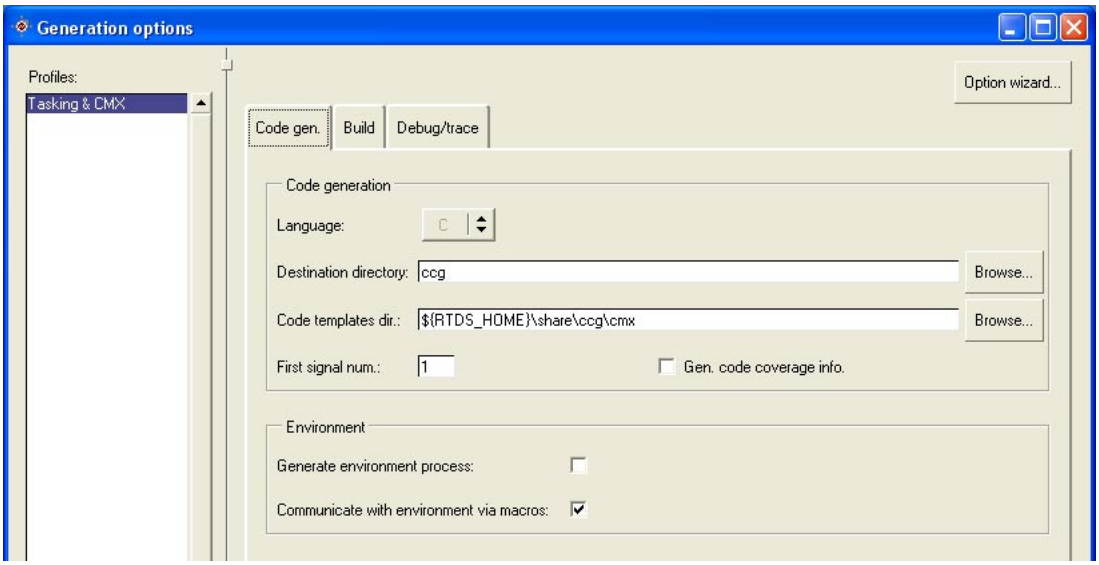
- Timer values are set in number of system ticks,
- CMX supports only counting semaphores with a FIFO queueing mechanism. SDL-RT mutex and binary semaphores have been mapped to counting semaphore,
- The SDL-RT process priorities are the ones of CMX. The default value is 150.
- When an SDL-RT task is deleted, its stack is not claimed. This is because the CMX `K_Task_Delete` does not free the stack space. Therefore systems creating and deleting a lot of tasks will run out of stack after a while. If dynamic creation and deletion is necessary the user should the CMX integration files the following way:
  - add a stack address field in the `RTDS_GlobalProcessInfo` structure in `RTDS_OS.h` file,
  - manually allocate memory for stack and store it in the `RTDS_globalProcessInfo` chained list,
  - use the `K_Task_Create_Stack` function instead of the `K_Task_Create`, in function `RTDS_ProcessCreate` in `RTOS_OS.c` file,
  - free the memory allocated for the stack after the `K_Task_Delete` in function `RTDS_ProcessKill` in `RTDS_OS.c` file.

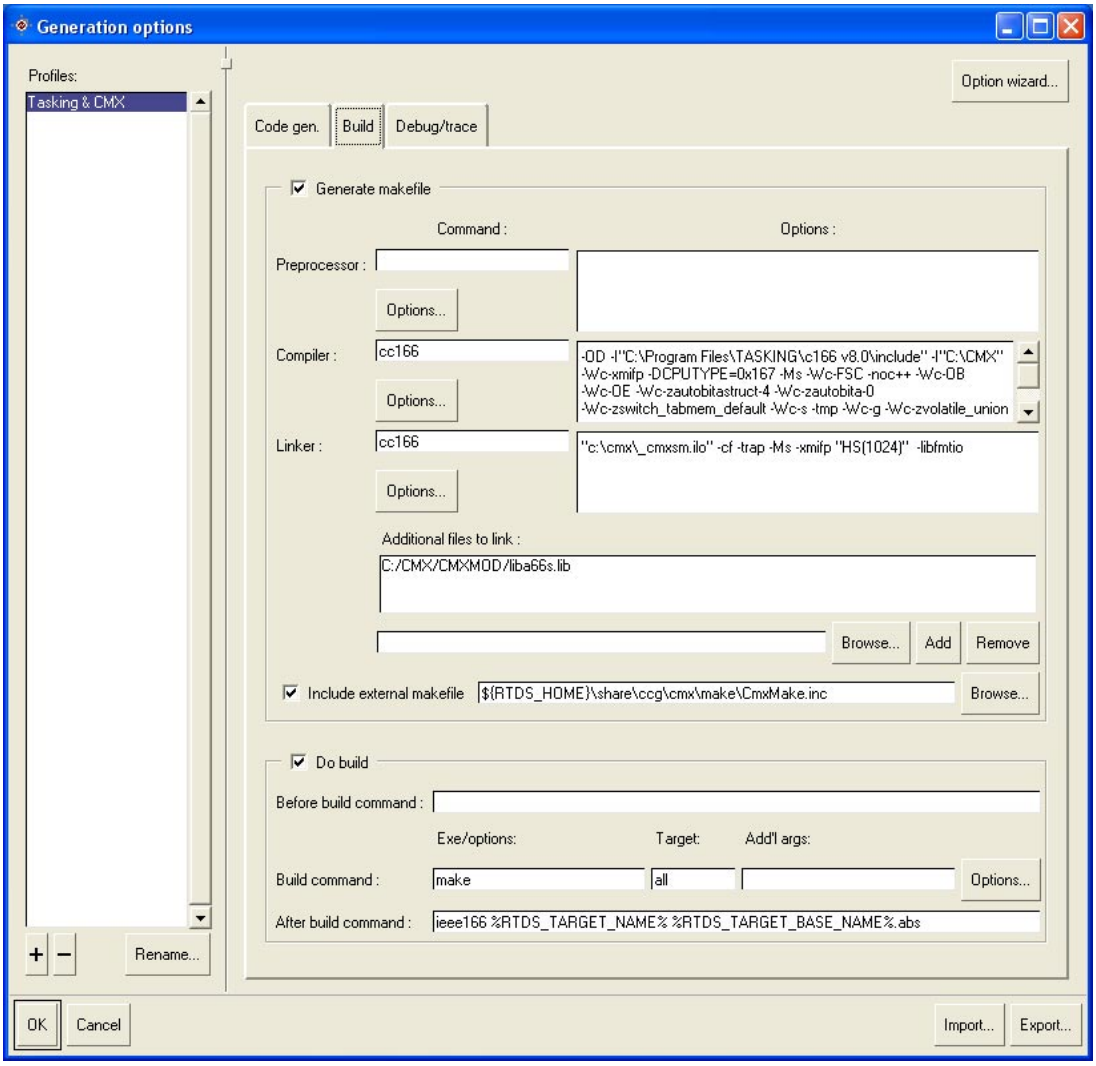
  Please read CMX manual chapters on stacks and on `K_Task_Create_Stack` function for implementation details.

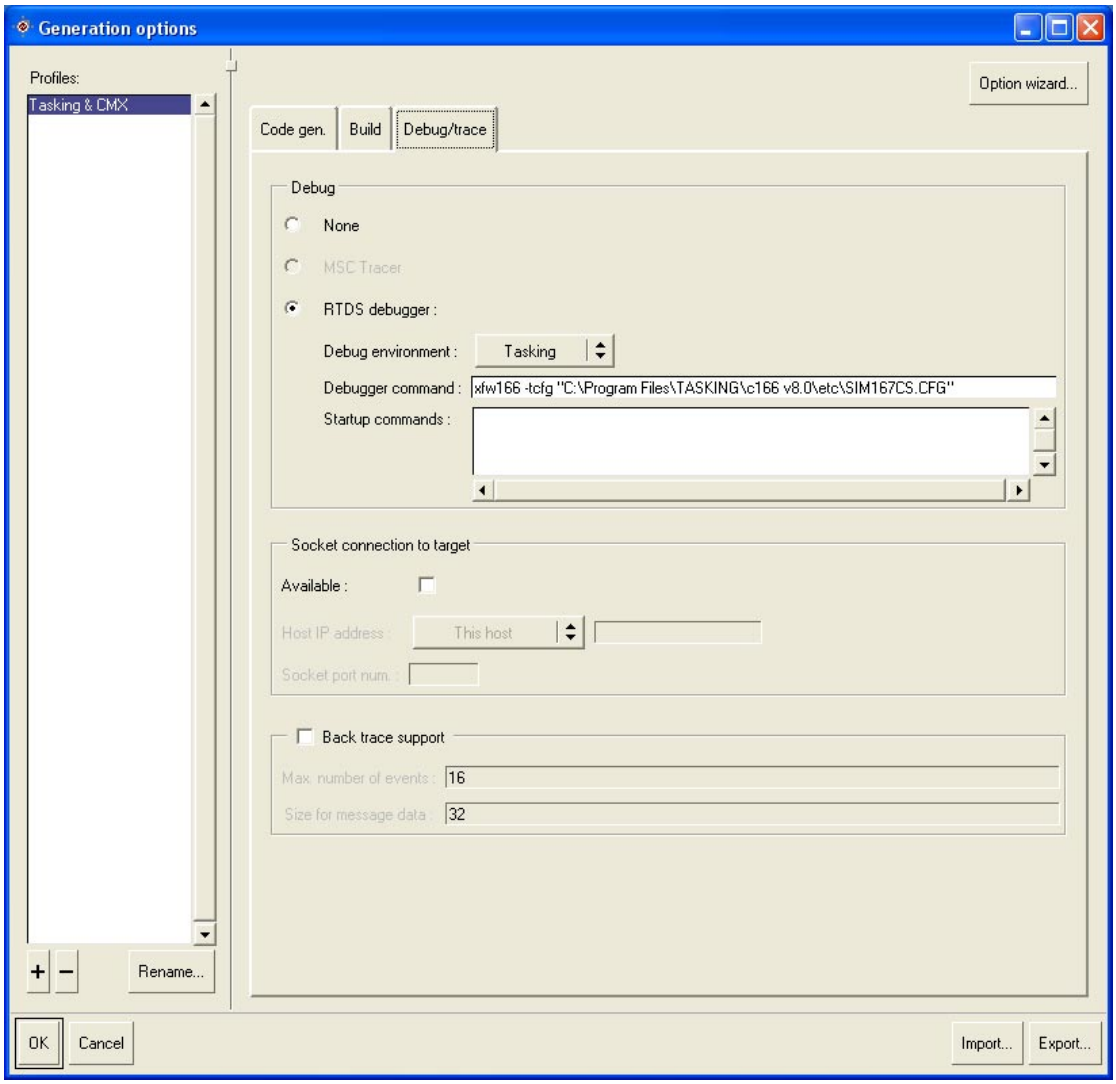
Tasking profile for CMX has the following characteristics:

- *CMX* RTOS needs to be compiled with the application because SDL-RT debugger will look for some CMX symbols. In order to do so:
  - *Include external makefile* can be used to compile CMX kernel
  - *Additional files to link* can be used to link with CMX libraries
- a utility is needed to generate the final code such as the *ieee166*. To do so the *After compil.* command can be used but watch the file names:
  - the target file name after the makefile is done is referenced by `%RTDS_TARGET_NAME%`,
  - the target file name without extension is referenced by `%RTDS_TARGET_BASE_NAME%`,
  - the SDL-RT debugger will try to load the `<SDL-RT system name>.abs` first and `<SDL-RT system name>.exe` if it did not work.

Last but not least the debugger command uses a configuration file so that the debugger is properly set up straight away. Check Tasking manuals for more information.







Typical generation profile to debug with Tasking a CMX application

Please note the Cygwin make is used in the generation profile above.

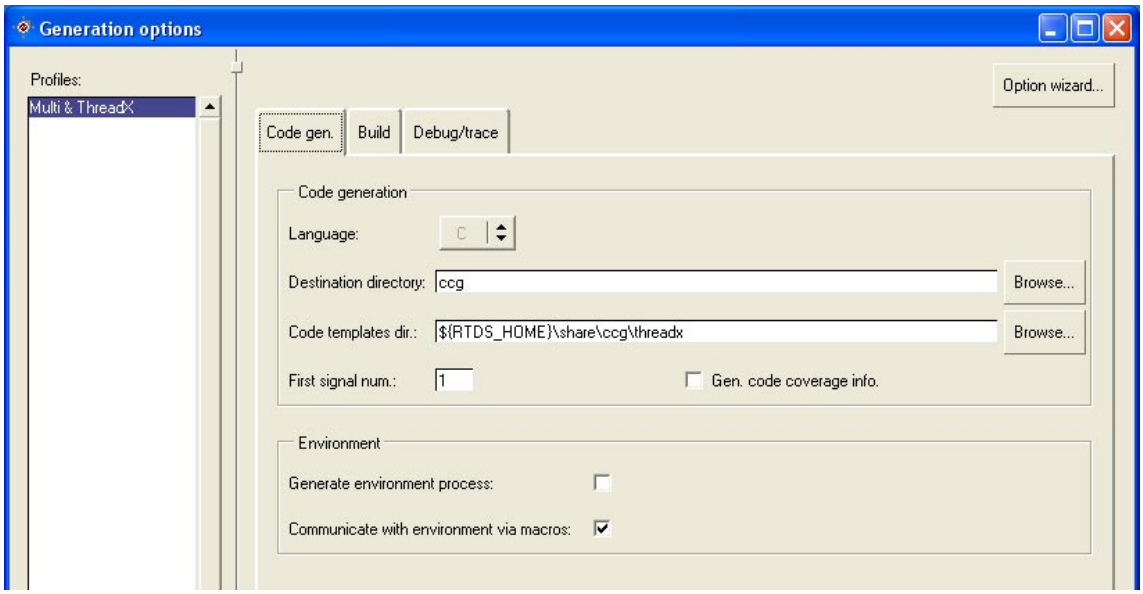
5.3.2.5 ThreadX profile

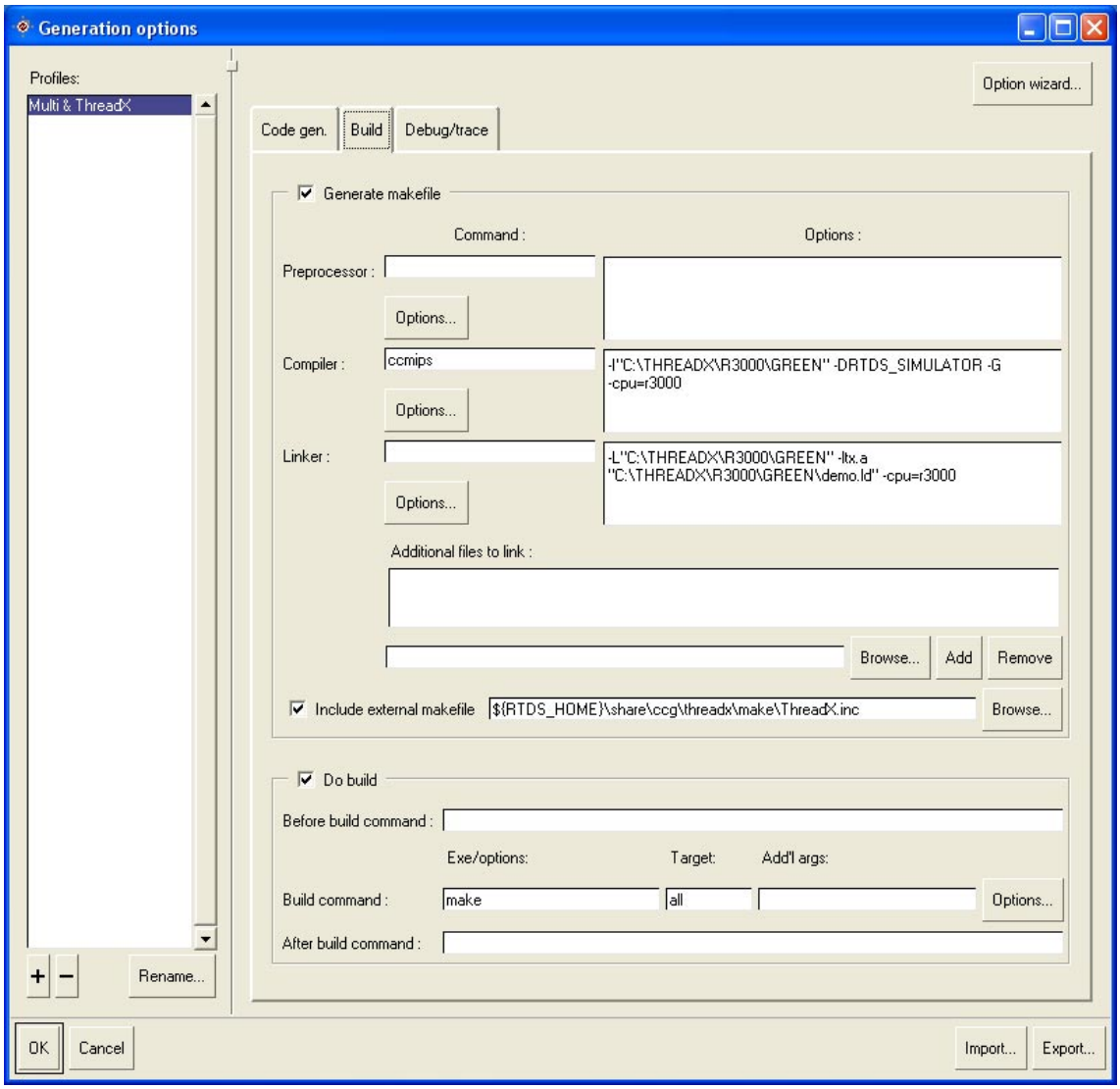
Real Timer Developer Studio includes a *Code template directory* to generate *ThreadX* applications.

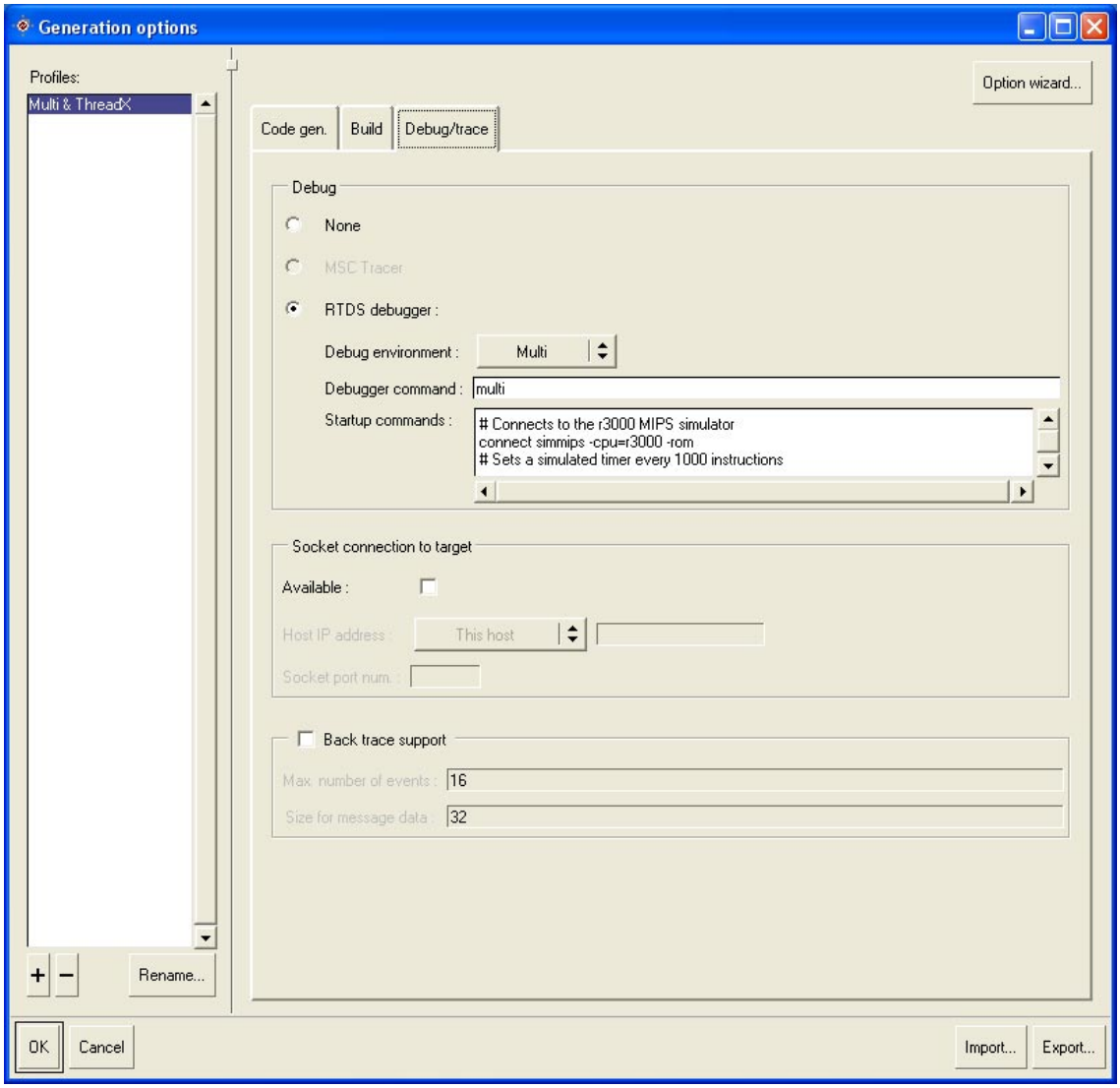
The profile characteristics are:

- Timer values are set in number of system ticks,
- ThreadX supports counting semaphores and mutex with FIFO queueing mechanism. SDL-RT counting and binary semaphores have been mapped to counting semaphore,
- The SDL-RT process priorities are the ones of ThreadX. Valid numerical priorities range between 0 and 31, where a value of 0 indicates the highest thread priority and a value of 31 represents the lowest thread priority. The default value is 15.

Here is an example profile to compile with Green Hills compiler:







Typical generation profile to compile a ThreadX application with Multi 2000 for MIPS

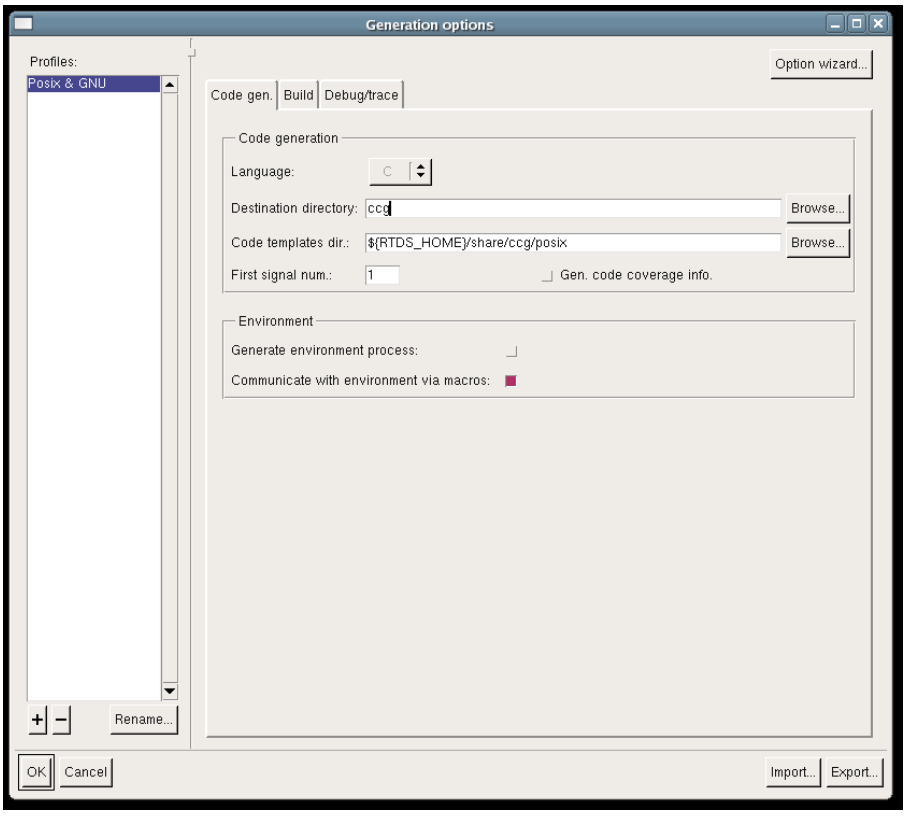
5.3.2.6 Posix profile

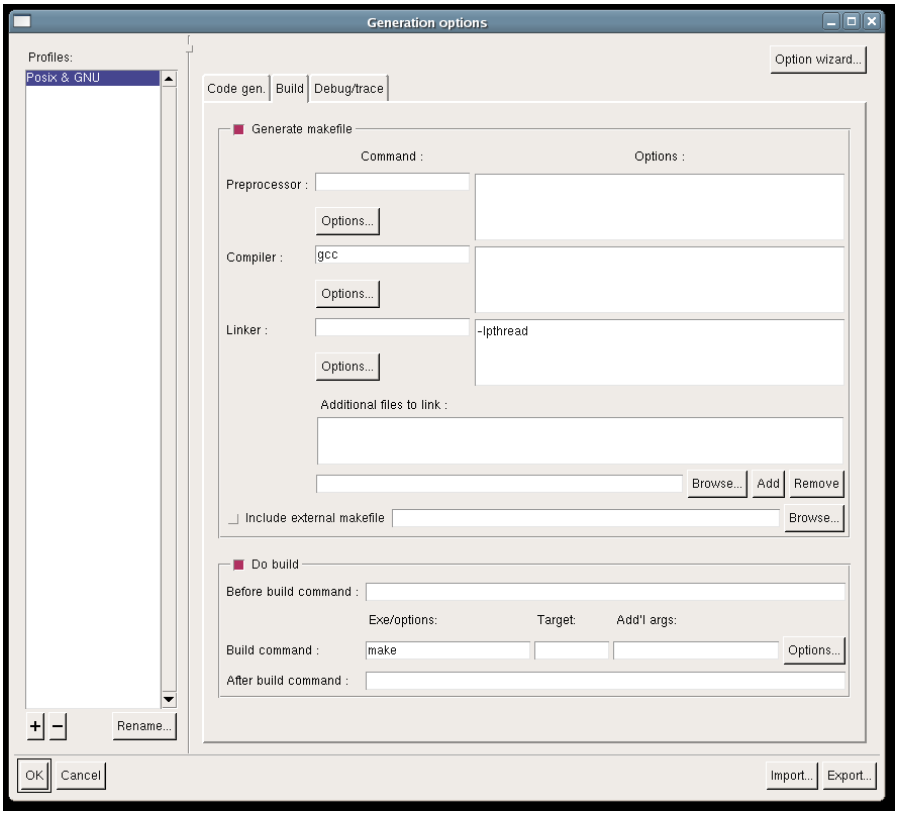
The profile characteristics are:

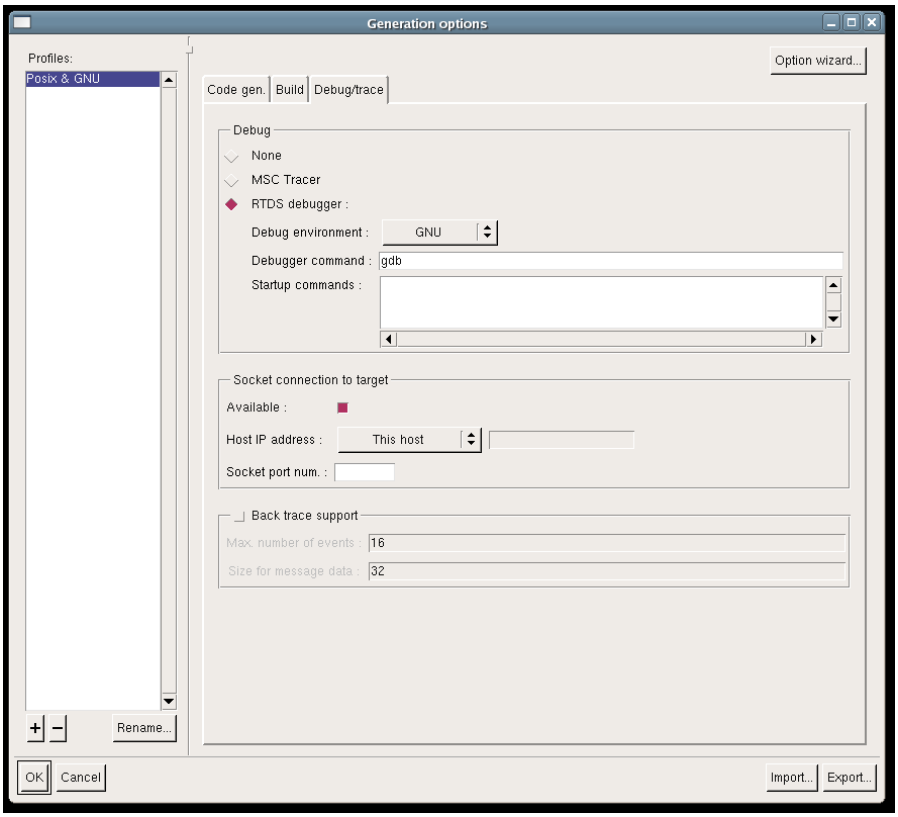
- Process creation
  SDL Task priority depend of the OS or RTOS you are using.
  - On **Solaris** the priority parameter should be between **0 and 59**
  - On **Linux** the priority parameter should be between **0 and 99**. Note the priority will only work if **user has superuser privilege**.

  Default SDL-RT priority is 20 for Solaris and 50 for Linux and for both platforms higher values correspond to higher priorities.
- Timers
  The time value is set in milliseconds.
- Semaphores
  - FIFO and PRIO parameters are ignored. Semaphore waiting queues are always FIFO based.
  - When using mutex semaphores DELETE_SAFE and INVERSION_SAFE have no effect.
  - When taking a semaphore the only options available are NO_WAIT and FOREVER and any other number of milliseconds will be understood as FOREVER.

Here is an example of Generation options for Posix under Linux:




Generation options
Profiles:
Posix & GNU
Option wizard...
Code gen.
Build
Debug/trace
Generate makefile
Command :
Options :
Preprocessor :
Options...
Compiler :
gcc
Options...
Linker :
-lpthread
Options...
Additional files to link :
Browse...
Add
Remove
Include external makefile
Browse...
Do build
Before build command :
Exe/options:
Target:
Add'l args:
Build command :
make
Options...
After build command :
Rename...
OK
Cancel
Import...
Export...


Generation options
Profiles:
Posix & GNU
Option wizard...
Code gen.
Build
Debug/trace
Debug
None
MSC Tracer
RTDS debugger :
Debug environment :
GNU
Debugger command :
gdb
Startup commands :
Socket connection to target
Available :
Host IP address :
This host
Socket port num. :
Back trace support
Max. number of events :
16
Size for message data :
32
Rename...
OK
Cancel
Import...
Export...

The code template directory is: `${RTDS_HOME}/share/ccg/posix`

The linker options depend on the target platform:

- Solaris
  `-lpthread -lrt`
- Linux
  `-lpthread`

Note: When debugging on Solaris with `gdb` the linker options are:

`-lpthread -lrt -lsocket -lnsl`

5.3.2.7 Windows profile

The profile characteristics are:

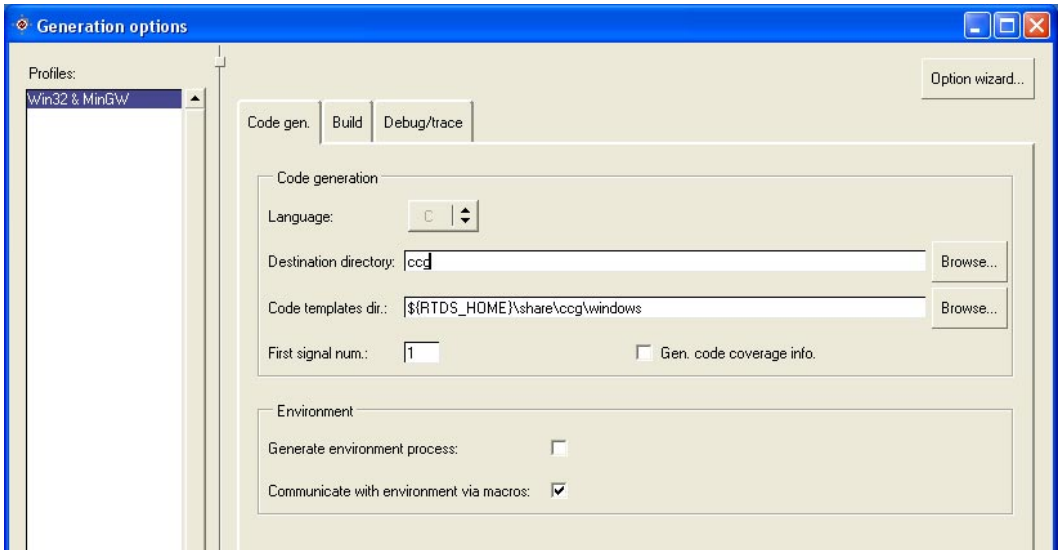
- Process creation
  The priority parameter should be one of the following numerical values defined in `winbase.h`:
  - `THREAD_PRIORITY_TIME_CRITICAL = 15`
  - `THREAD_PRIORITY_HIGHEST = 2`
  - `THREAD_PRIORITY_ABOVE_NORMAL = 1`
  - `THREAD_PRIORITY_NORMAL = 0`
  - `THREAD_PRIORITY_BELOW_NORMAL = -1`
  - `THREAD_PRIORITY_LOWEST = -2`
  - `THREAD_PRIORITY_IDLE = -1`

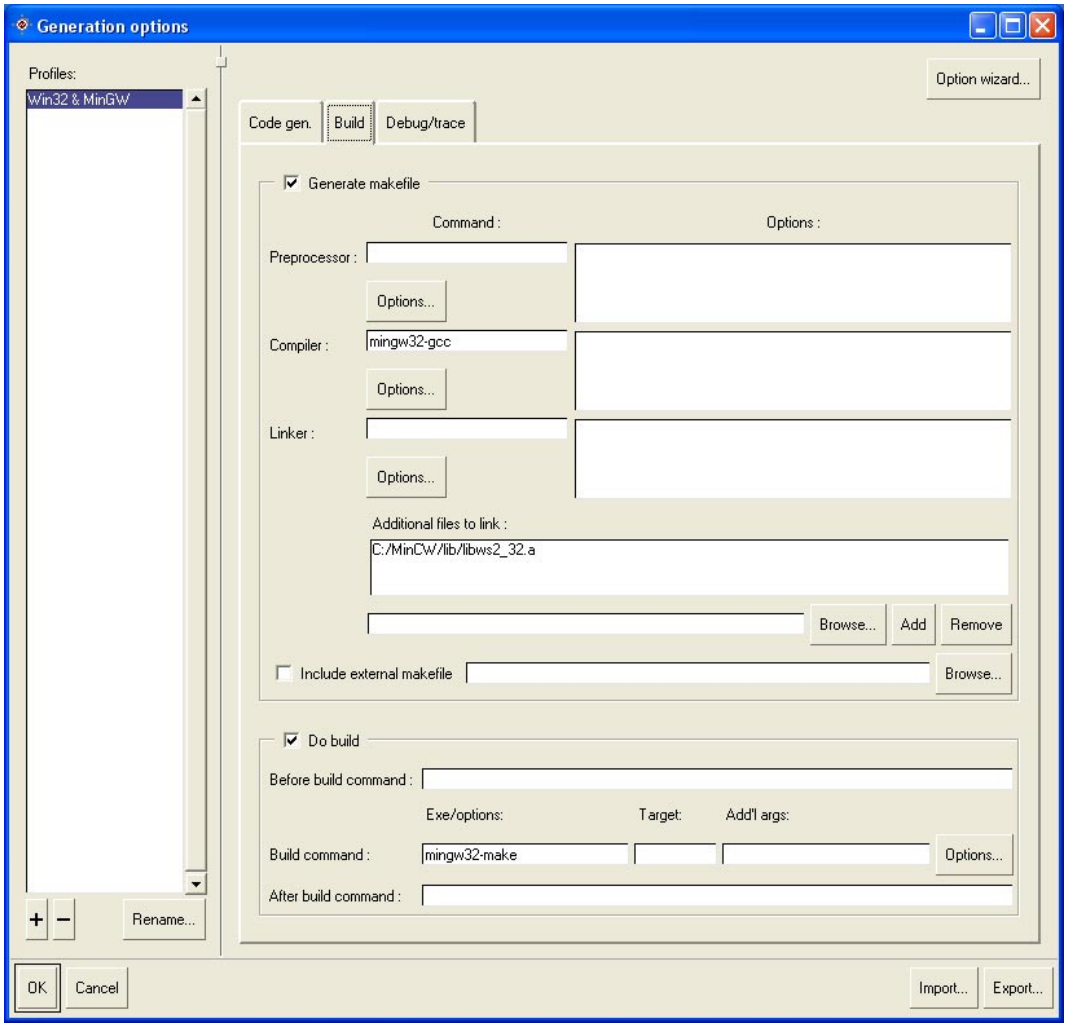
  Default SDL-RT priority is 0

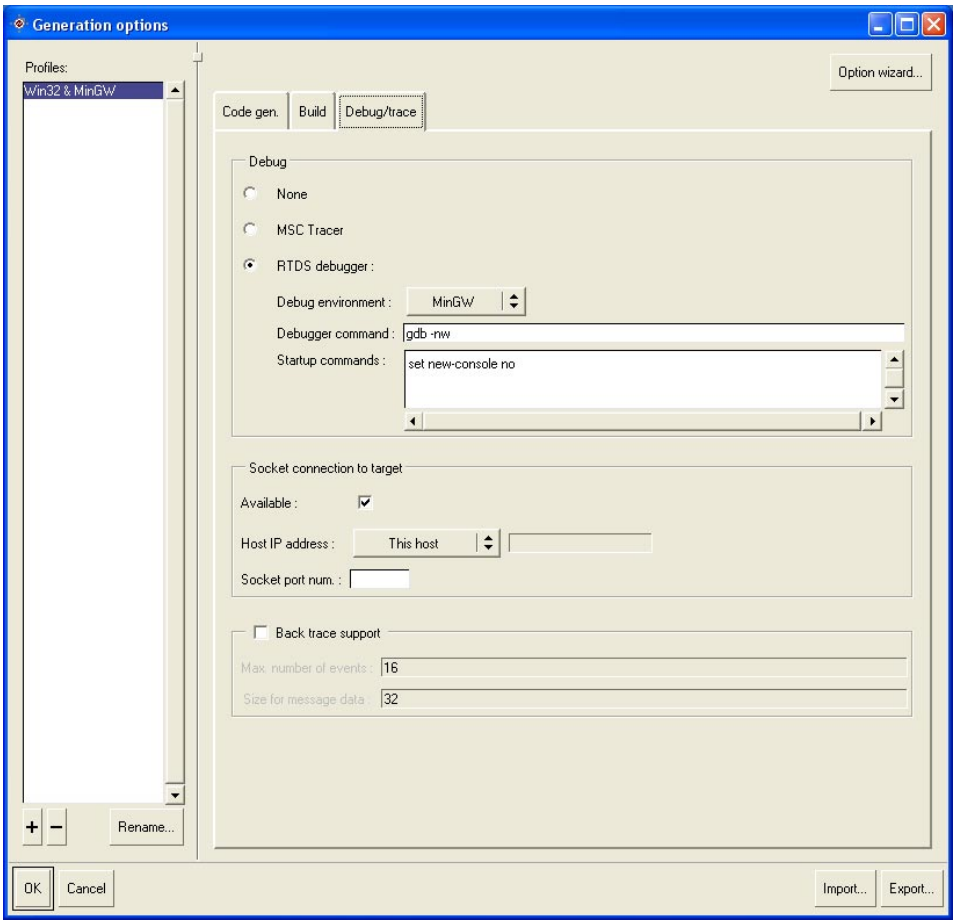
SDL-RT process definition and creation example with Windows priority

  In the current release it is not possible to use the macro itself. The numerical value should be used instead.
- Timers
  The time value is set in milliseconds.
- Semaphores
  - FIFO and PRIO parameters are ignored. Semaphore waiting queues are always FIFO based.
  - When using mutex semaphores DELETE_SAFE and INVERSION_SAFE have no effect.

Here is an example of Generation options for Windows with MinGW compiler, make utility and debugger :




Generation options
Profiles:
Win32 & MinGW
Rename...
Option wizard...
Code gen.
Build
Debug/trace
Generate makefile
Command :
Options :
Preprocessor :
Options...
Compiler :
mingw32-gcc
Options...
Linker :
Options...
Additional files to link :
C:/MinCW/lib/libws2_32.a
Browse...
Add
Remove
Include external makefile
Browse...
Do build
Before build command :
Exe/options:
Target:
Add'l args:
Build command :
mingw32-make
Options...
After build command :
OK
Cancel
Import...
Export...



The code template directory is:

`${RTDS_HOME}/share/ccg/windows`

Note: The debugger command should be `gdb -nw` and the console should be remove for MinGW version of gdb: `set new-console no`.

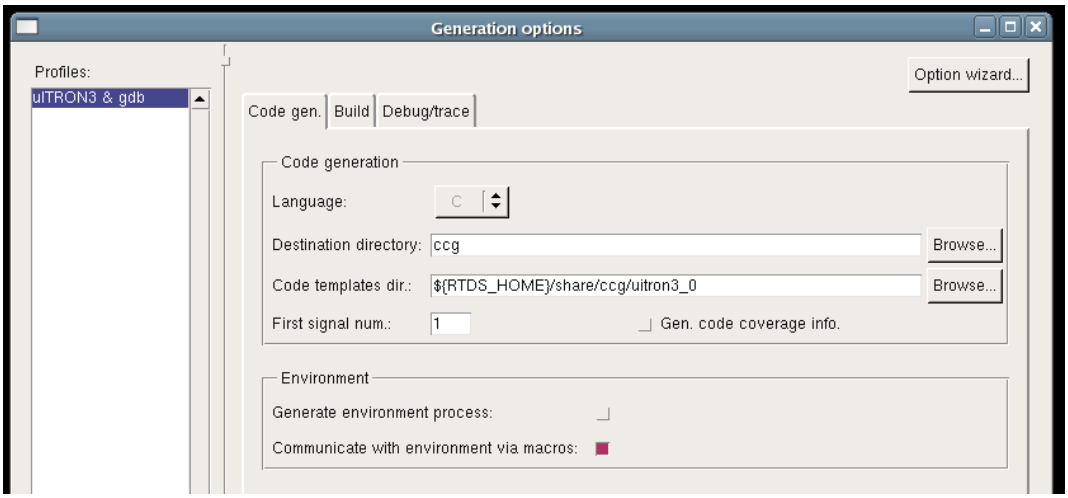
5.3.2.8 uITRON 3.0 profile

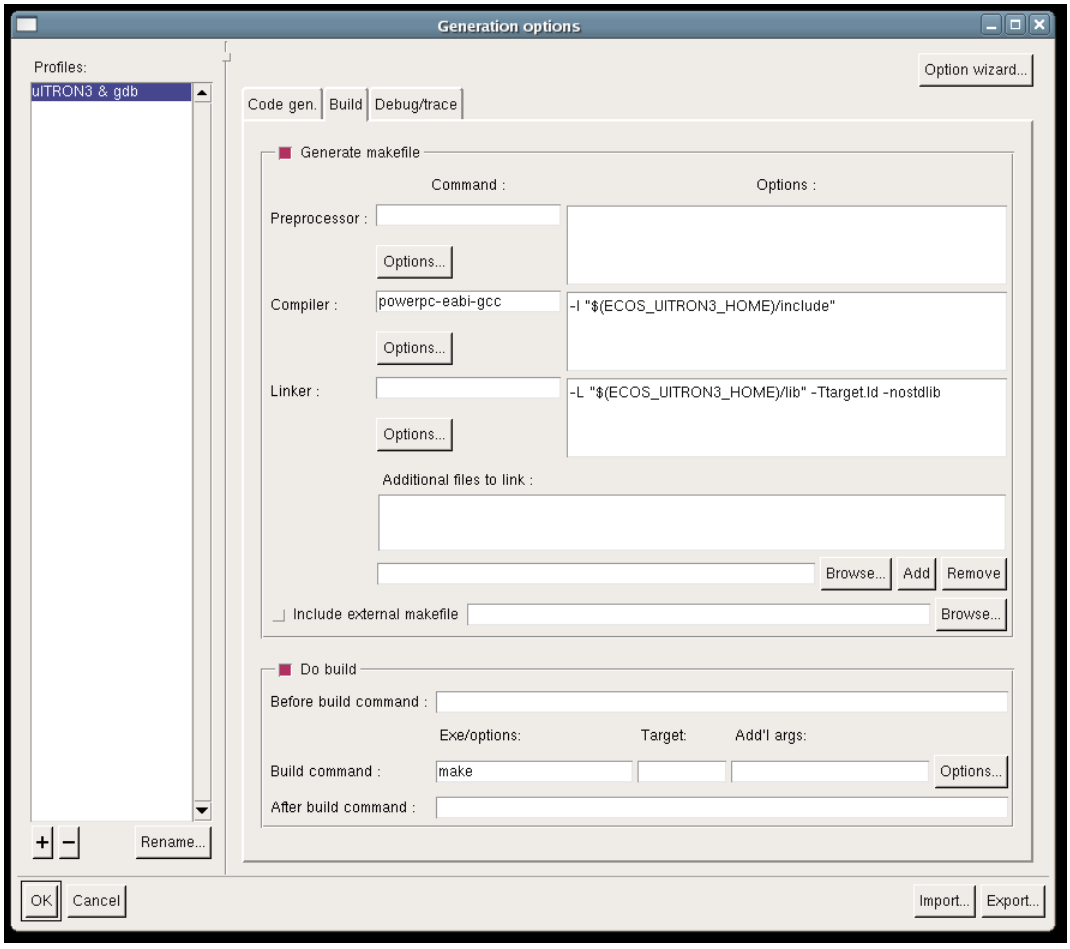
This Profile has been developed and tested under Windows with the uITRON interface for eCos, the XRAY debugger and the ARM emulator: Armulator.

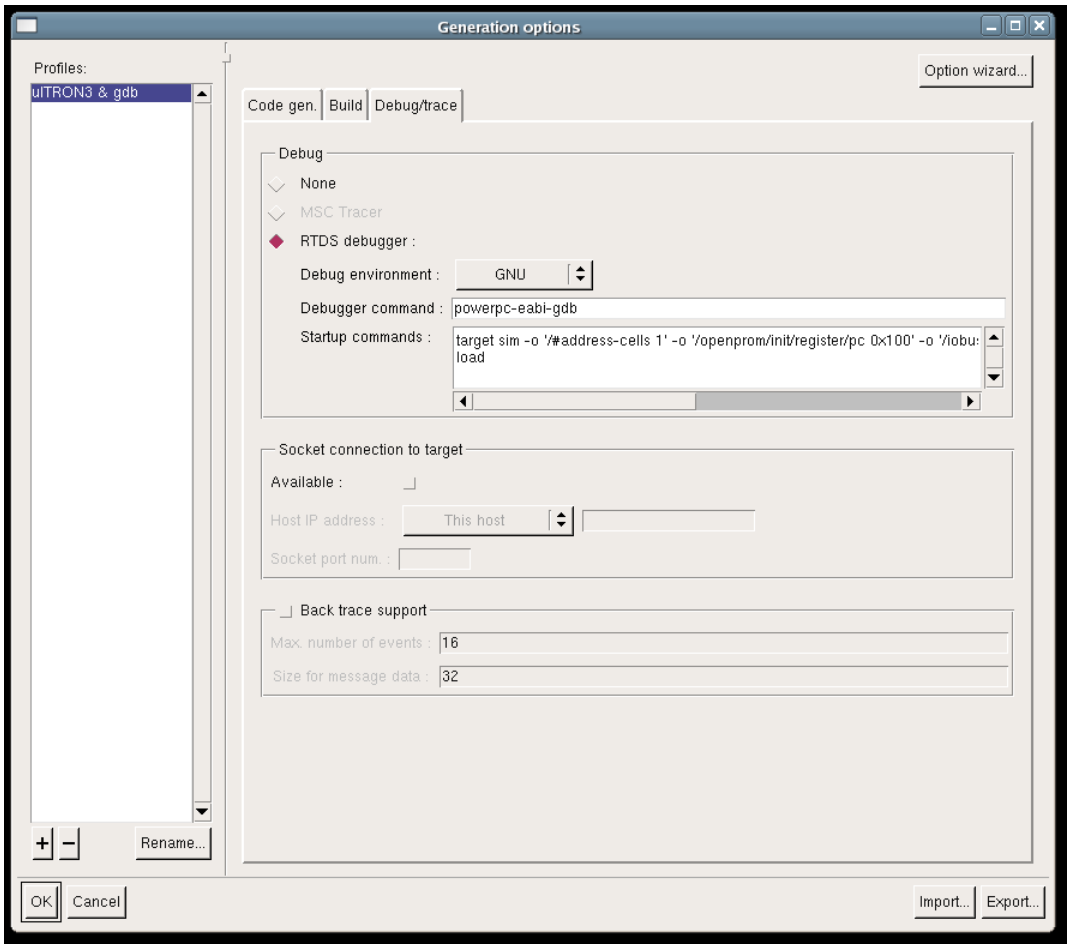
The profile characteristics are:

- Process creation
  uITRON 3.0 specification allows task priorities between 1 and 8. The smaller the value, the higher the priority. Default SDL-RT task priority is 4.
- Timer
  SDL-RT timers are mapped on uITRON alarm mechanism. The SDL-RT time out value is used as is in the alarm parameter.
- Message
  SDL-RT messages are mapped uITRON mailbox mechanism.
- Semaphores
  - All three types of semaphore are based on uITRON counting semaphore.
  - When using mutex semaphores, DELETE_SAFE and INVERSION_SAFE have no effect.

Here is an example of Generation options for uITRON as implemented in eCos:







The code template directory is:

```
${RTDS_HOME}/share/ccg/uitron3_0
```

The linker options depend on the RTOS and should add the uITRON library path. for example when using eCos's uITRON interface you should add:

```
-L [uITRON_Library_Path] -Ttarget.ld -nostdlib
```

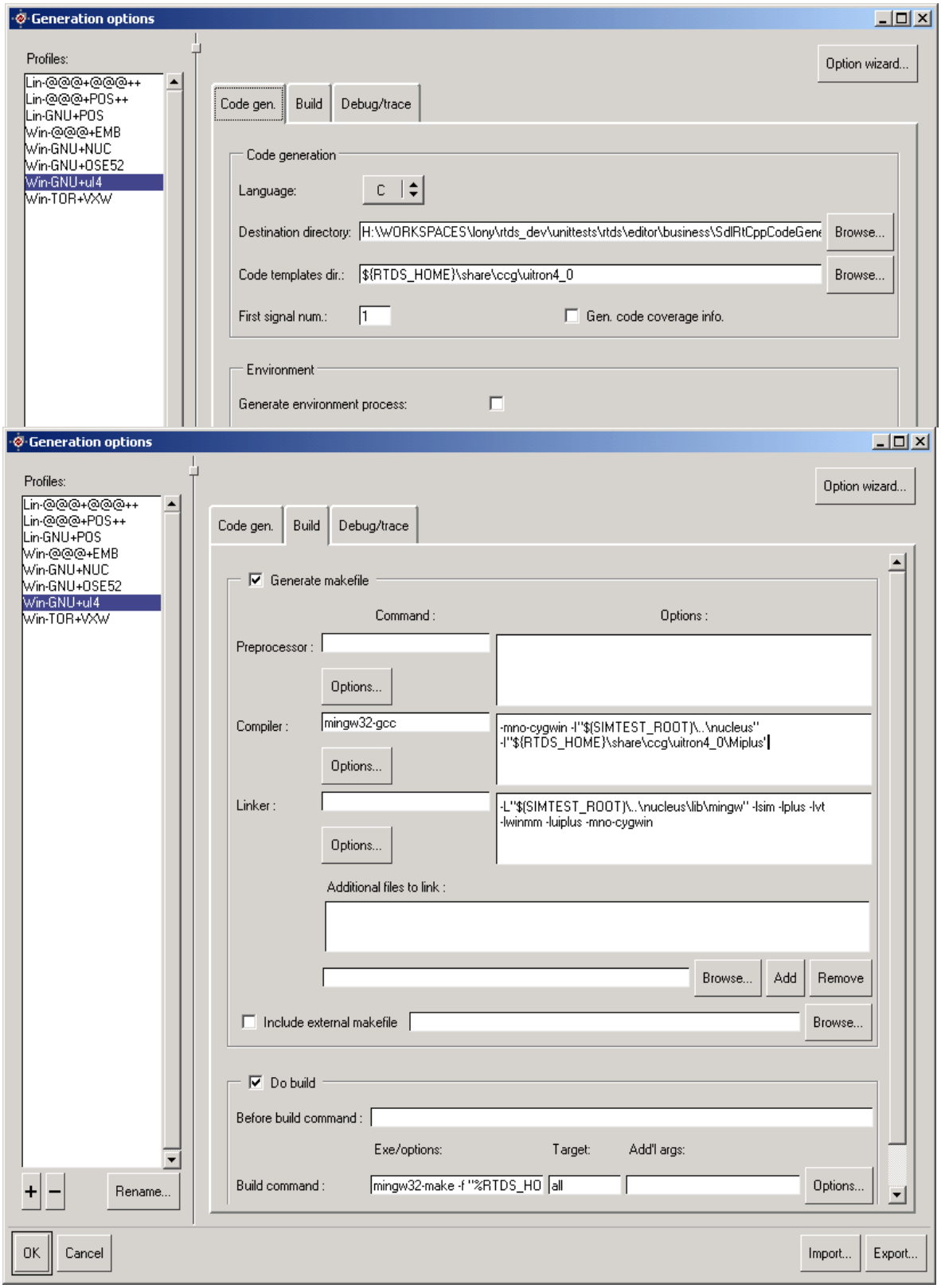
5.3.2.9 uITRON 4.0 profile

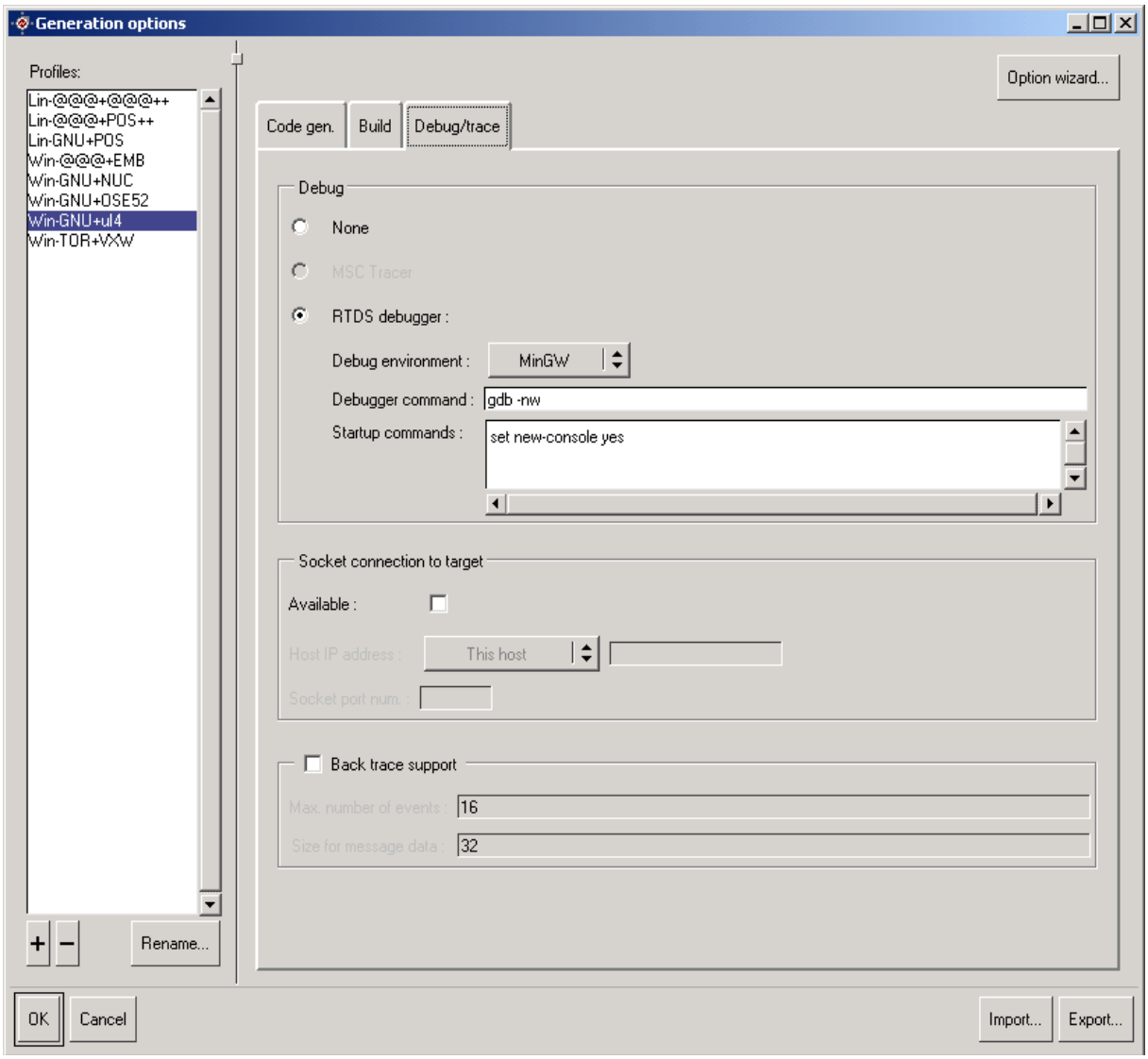
This Profile has been tested under Windows with the uITRON interface for NUCLEUS and MinGW GDB debugger.

The profile characteristics are:

- Process creation
  uITRON 4.0 specification allows task priorities between 1 and 16. Nucleus uITRON API allows to use 1 to 255 task priorities. Default SDL-RT task priority is 4.
- Timer
  SDL-RT timers are mapped on uITRON alarm mechanism. The SDL-RT time out value is used as is in the alarm parameter.
- Message
  SDL-RT messages are mapped uITRON mailbox mechanism.
- Semaphores
  - Only binary and counting semaphores are supported
  - These two types of semaphore are based on uITRON counting semaphore.
  - When using mutex semaphores, an error is raised

Here is an example of Generation options for uITRON as implemented in NUCLEUS





The code template directory is:

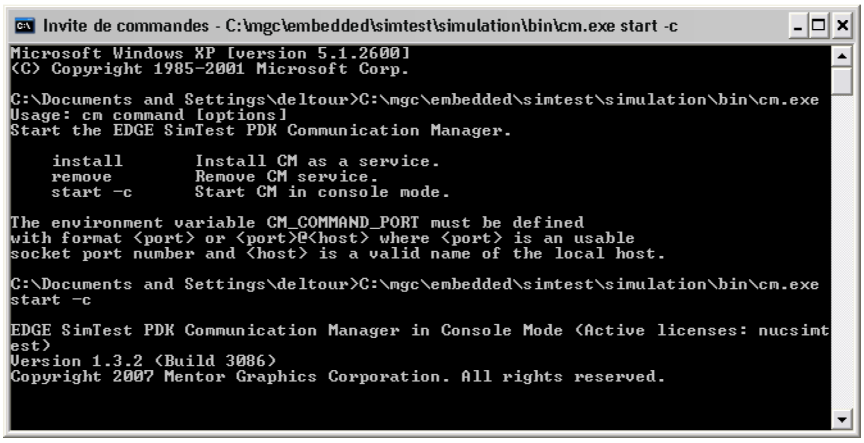
```
${RTDS_HOME}/share/ccg/uitron4_0
```

The linker options depend on the RTOS and should add the uITRON 4.0 library path. for example when using NUCLEUS's uITRON 4.0 interface you should add:

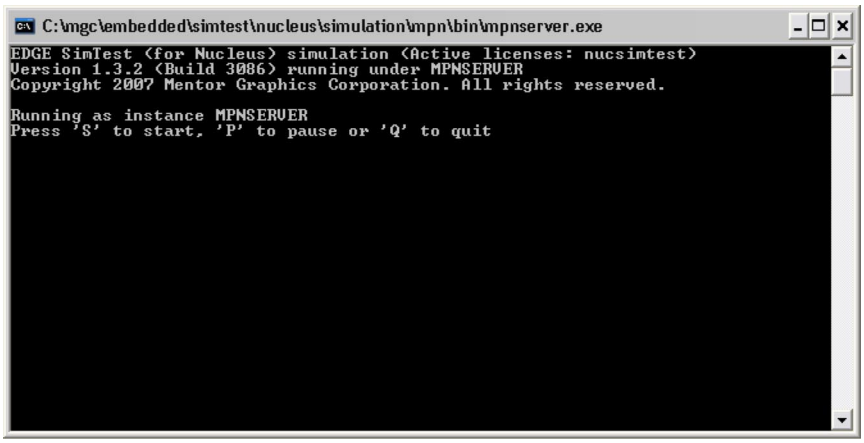
```
-L"NUCLEUS_uiPLUS_path" -lsim -lplus -lvt -lwinmm -luiplus -mno-cygwin
```

In order to debug a uITRON4 application with SimTest kernel simulator, some manual operations are required:

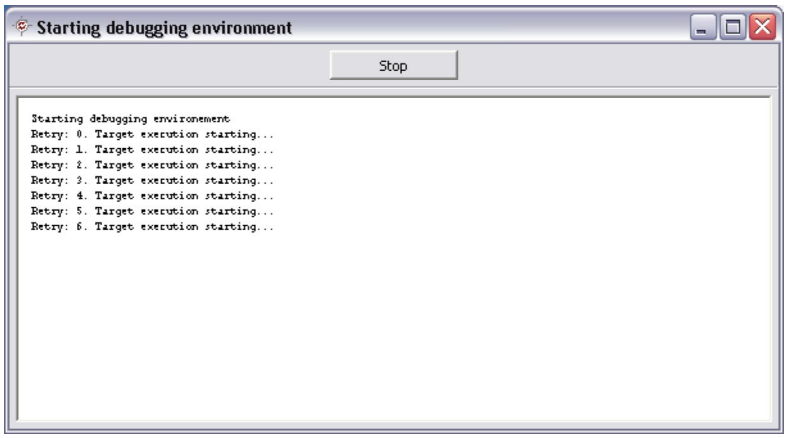
- Start the EDGE communication manager:
  `%SIMTEST_ROOT%\bin\cm.exe start -c`


Invite de commandes - C:\mgc\embedded\simtest\simulation\bin\cm.exe start -c
Microsoft Windows XP [version 5.1.2600]
(C) Copyright 1985-2001 Microsoft Corp.
C:\Documents and Settings\deltour>C:\mgc\embedded\simtest\simulation\bin\cm.exe
Usage: cm command [options]
Start the EDGE SimTest PDK Communication Manager.
install Install CM as a service.
remove Remove CM service.
start -c Start CM in console mode.
The environment variable CM_COMMAND_PORT must be defined
with format <port> or <port>@<host> where <port> is an usable
socket port number and <host> is a valid name of the local host.
C:\Documents and Settings\deltour>C:\mgc\embedded\simtest\simulation\bin\cm.exe
start -c
EDGE SimTest PDK Communication Manager in Console Mode (Active licenses: nucsimt
est)
Version 1.3.2 (Build 3086)
Copyright 2007 Mentor Graphics Corporation. All rights reserved.

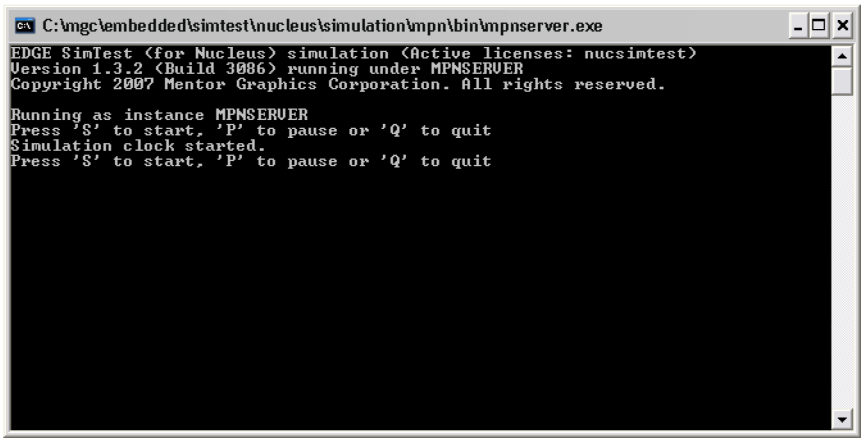
- Start the MPN server:
  `%SIMTEST_ROOT%\..\nucleus\simulation\mpn\bin\mpnserver.exe`


C:\mgc\embedded\simtest\nucleus\simulation\mpn\bin\mpnserver.exe
EDGE SimTest (for Nucleus) simulation (Active licenses: nucsimtest)
Version 1.3.2 (Build 3086) running under MPNSERVER
Copyright 2007 Mentor Graphics Corporation. All rights reserved.
Running as instance MPNSERVER
Press 'S' to start, 'P' to pause or 'Q' to quit

- Start RTDS debugger, when the debugger tries to connect to the executable:


Starting debugging environment
Stop
Starting debugging environement
Retry: 0. Target execution starting...
Retry: 1. Target execution starting...
Retry: 2. Target execution starting...
Retry: 3. Target execution starting...
Retry: 4. Target execution starting...
Retry: 5. Target execution starting...
Retry: 6. Target execution starting...

- Then type 'S' in the MPN server window:


C:\mgc\embedded\simtest\nucleus\simulation\mpn\bin\mpnserver.exe
EDGE SimTest (for Nucleus) simulation (Active licenses: nucsimtest)
Version 1.3.2 (Build 3086) running under MPNSERVER
Copyright 2007 Mentor Graphics Corporation. All rights reserved.
Running as instance MPNSERVER
Press 'S' to start, 'P' to pause or 'Q' to quit
Simulation clock started.
Press 'S' to start, 'P' to pause or 'Q' to quit

Then the debugger can connect to the target and you can debug normally.

5.3.2.10 OSE Delta 4.5.2 profile

Real Timer Developer Studio includes a *Code template directory* to generate *OSE* applications and the SDL-RT debugger is interfaced with *gdb* providing a consistent environment.

The profile characteristics are:

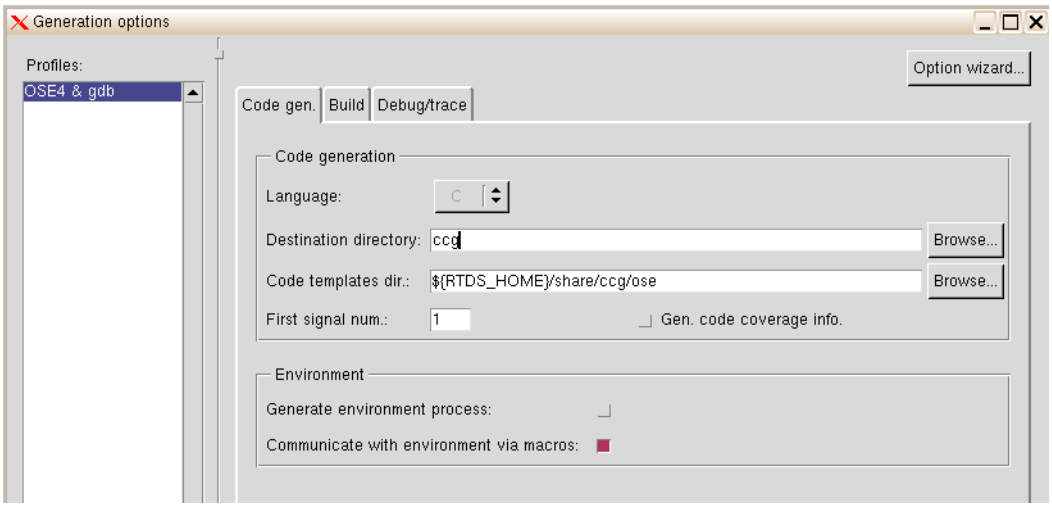
- Build process
  The OSE build process is based on `dmake` utility and `makefile.mk` and `userconf.mk` makefiles. When using OSE code generation, RTDS generates `pragmadev.mk` makefile in the code generation directory. The `makefile.mk` and `userconf.mk` should be put somewhere else because they are not generated file and `makefile.mk` must include the generated `pragmadev.mk` file. For example:
  ```
  include .$/pragmadev.mk
  ```
  The make command should set the target to RTDS_ALL. For example under windows:
  ```
  dmake -f ../makefile.mk RTDS_ALL RTDS_HOME=%RTDS_HOME%
  ```
  or under Unix:
  ```
  dmake -f ../makefile.mk RTDS_ALL RTDS_HOME=$RTDS_HOME
  ```
- SDL-RT system start
  The pragmadev.mk generated file includes `${RTDS_HOME}\share\ccg\ose\make\OseMake.inc` that tells OSE kernel to statically start RTDS_Start process:
  ```
  PRI_PROC(RTDS_Start, RTDS_Start, 1024, 15, DEFAULT, 0,
  NULL)
  ```
  That means SDL-RT static process are not defined as static to OSE kernel. RTDS startup procedure takes care of creating the processes and synchronizing them.
- Timers handling
  SDL-RT timers are based on OSE Time-Out Server (TOSV). TOSV should therefore be included in `userconf.mk file`:
  ```
  INCLUDE_OSE_TOSV     *= yes
  ```
- Priorities
  SDL-RT process priorities are the ones of OSE. The default value is 15.
- Memory management
  RTDS generated code memory allocation `RTDS_MALLOC` and `RTDS_FREE` are based on `heap_alloc_shared` and `heap_free_shared` OSE functions. This is because it happens a process frees memory allocated by another process.
- Signal header and definitions
  All generated OSE signals will have the following RTDS header:
  ```
  typedef struct RTDS_MessageHeader
    {
    SIGSELECT          sigNo;
    long               messageNumber;
    long               timerUniqueId;
    RTDS_QueueId       sender;
    long               dataLength;
    unsigned char      *pData;
  ```

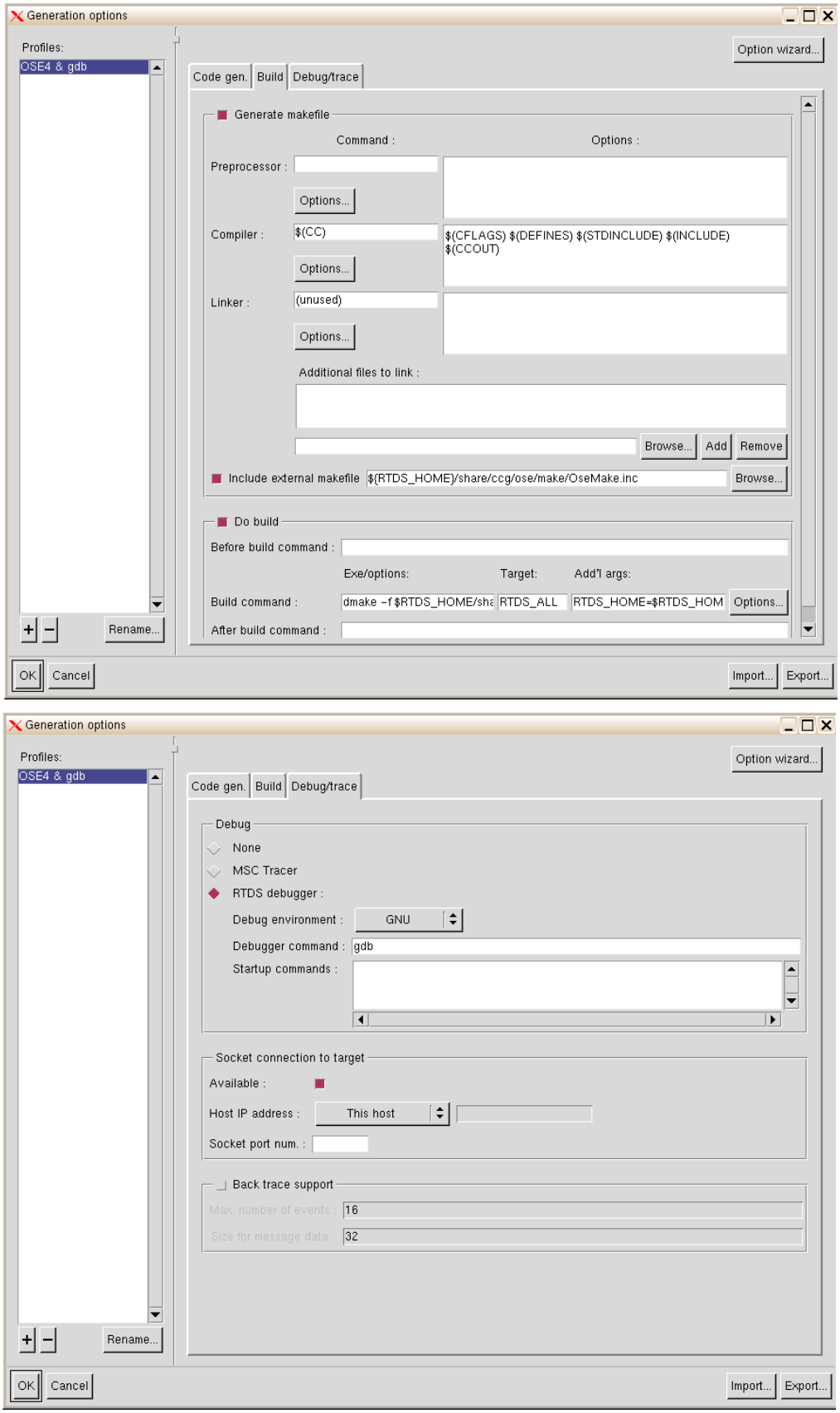
```
  struct RTDS_MessageHeader       *next;
  } RTDS_MessageHeader;

typedef union SIGNAL
  {
  SIGSELECT sigNo;
  struct RTDS_MessageHeader messageHeader;
  }SIGNAL;
```

An OSE signal file is generated that contains all SDL-RT signal definitions: RTDS_gen.sig. All signals have the RTDS_MessageHeader data content. Below is an example of a generated signal file:

```
#include "ose.h"
#include "RTDS_OS.h"

#define ping  (1) /* !-SIGNO(struct RTDS_MessageHeader)-!
*/
#define tWait (2) /* !-SIGNO(struct RTDS_MessageHeader)-!
*/
#define pong  (3) /* !-SIGNO(struct RTDS_MessageHeader)-!
*/
#define begin (4) /* !-SIGNO(struct RTDS_MessageHeader)-!
*/
#define myStart (5) /* !-SIGNO(struct RTDS_MessageHeader)-!
*/
#define myStop  (6) /* !-SIGNO(struct RTDS_MessageHeader)-!
*/
```

Below is an OSE generation profile example with debug based on gdb:





Typical generation profile to debug an OSE application with gdb

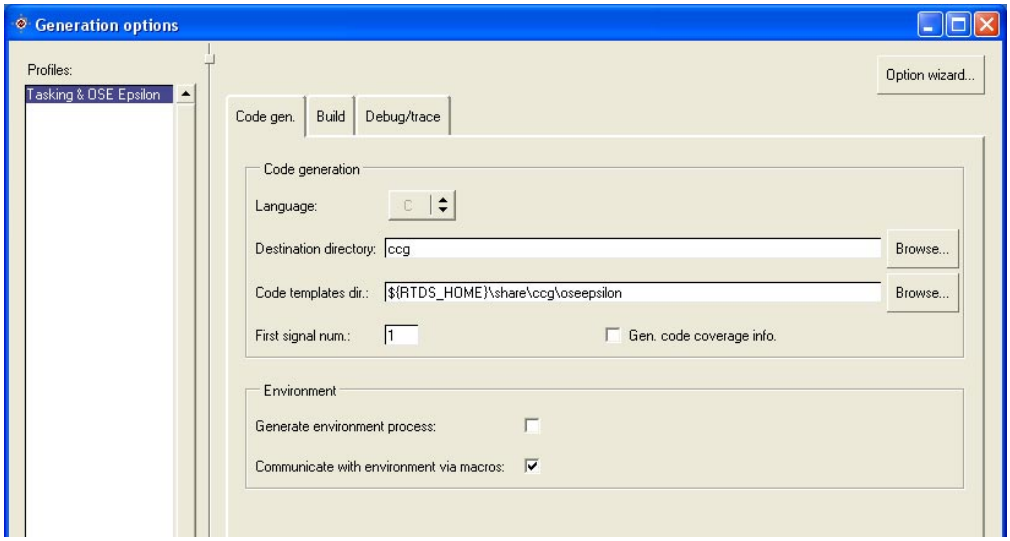
5.3.2.11 OSE Epsilon profile

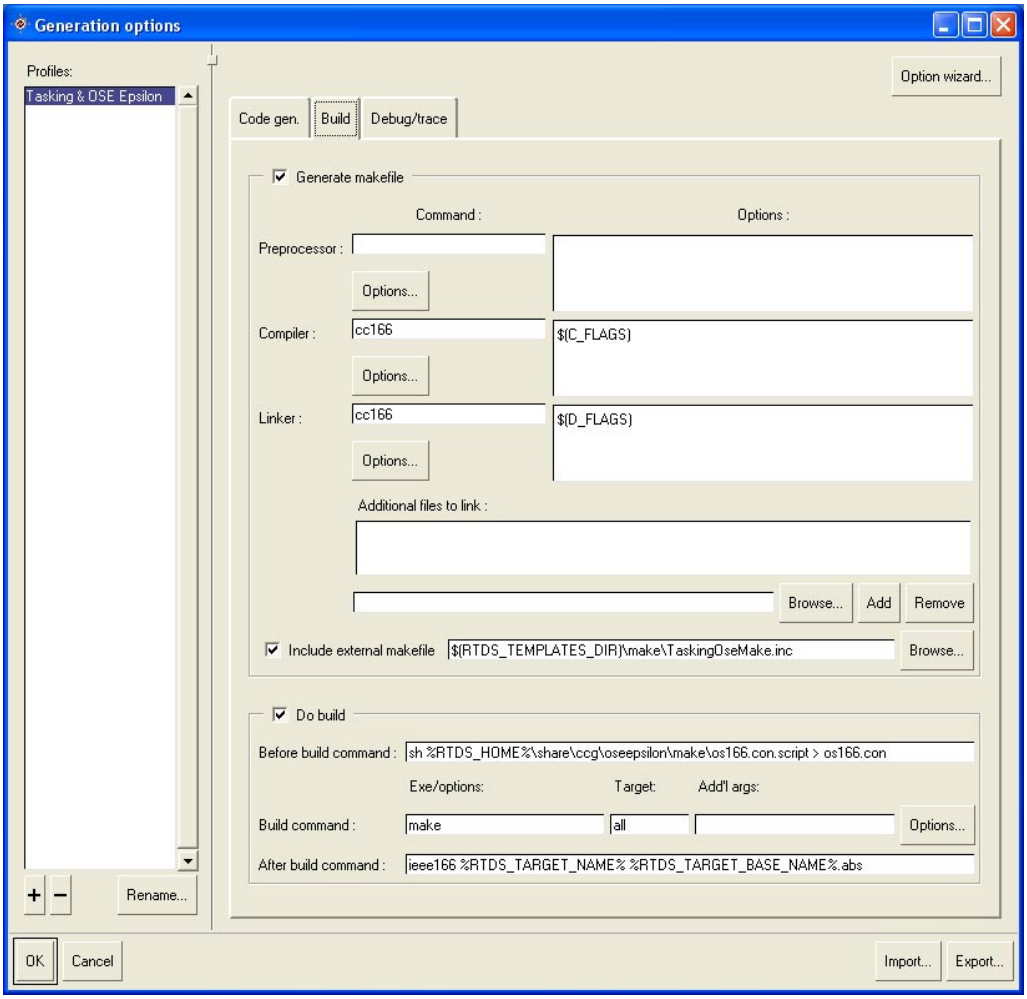
Real Timer Developer Studio includes a *Code template directory* to generate *OSE Epsilon* applications.

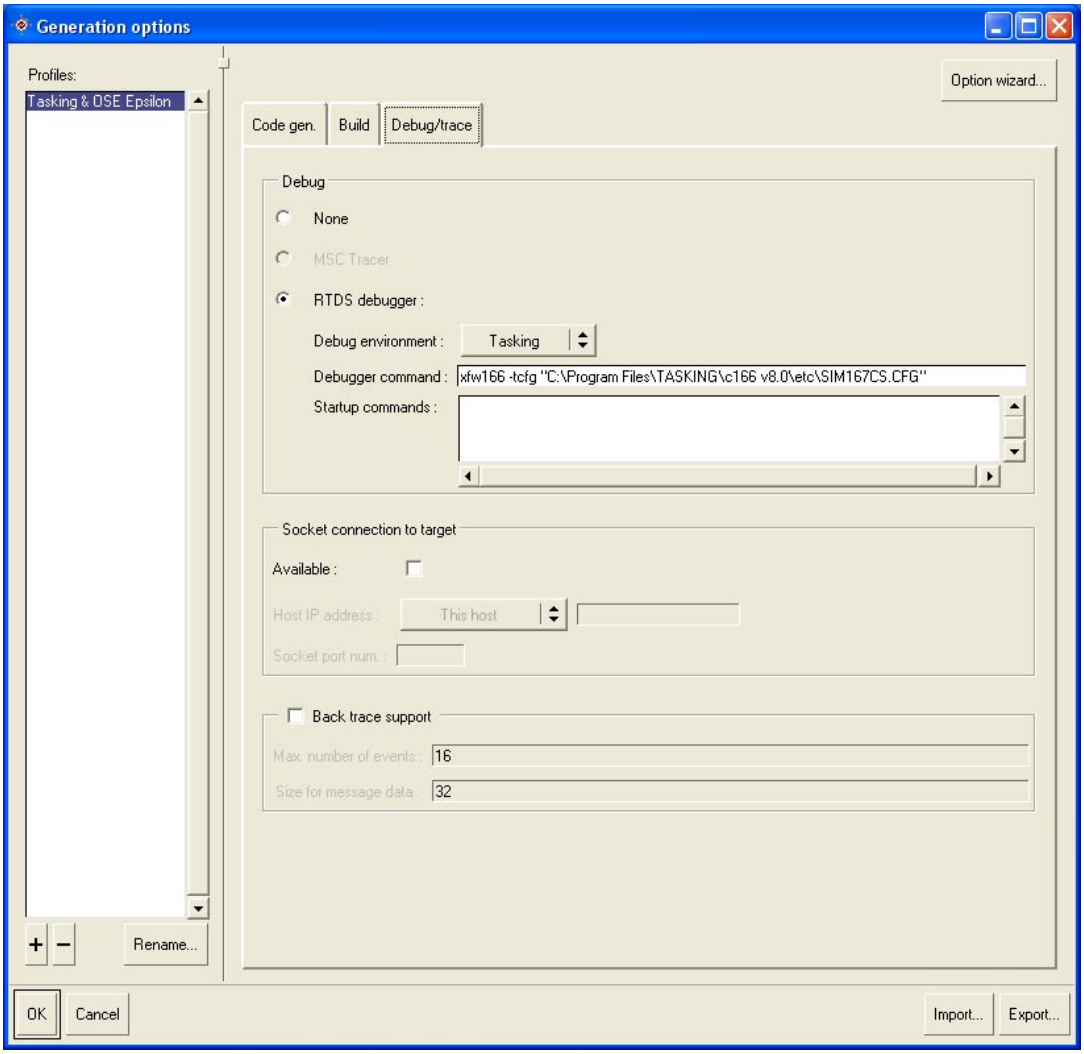
The profile characteristics are:

- Build process
  OSE Epsilon is a static RTOS. That means the RTOS is compiled with the application and no dynamic task creation is possible. To do so OSE Epsilon needs to know at compile time the list of task in the system.
  During code generation, RTDS produces `RTDS_gen.inf` that contains the list of tasks, semaphores, and signals used in the system. A shell script based on awk extracts the necessary information out of the file and generates the OSE Epsilon `.con` file needed to configure the kernel. The templates provided in RTDS distribution are based to run with *Tasking C166* cross compiler. The *OSE Epsilon* file is built based on `os166.con.pre`, the result of the awk script and `os166.con.post`. These templates can be adapted to any processor or cross compiler.
- SDL-RT system start
  As a result of the `.con` file, OSE Epsilon will start all task by itself at startup. RTDS_Start task is started with the highest priority in order to initialize the execution environment: create semaphores, message unique id pool, and back trace circular buffer.
  All other task will create their own context variable and wait a very short delay to let the other tasks do the same.
- Timers handling
  SDL-RT timers are based on OSE Time-Out Server (TOSV). TOSV should therefore be included in the `.con` file:
  `%TI_PROC  tosv,C,256,256,1`
- Memory management
  RTDS generated code memory allocation `RTDS_MALLOC` and `RTDS_FREE` are based on `malloc` and `free` functions.

The example profile given below is based on Tasking C166 cross compiler:







Typical generation profile to debug an OSE Epsilon application with Tasking

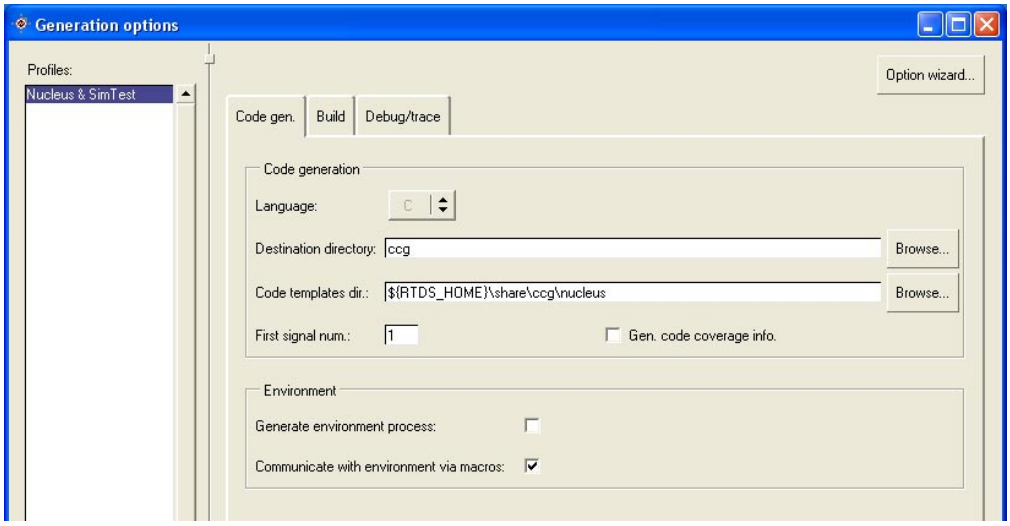
5.3.2.12 Nucleus profile

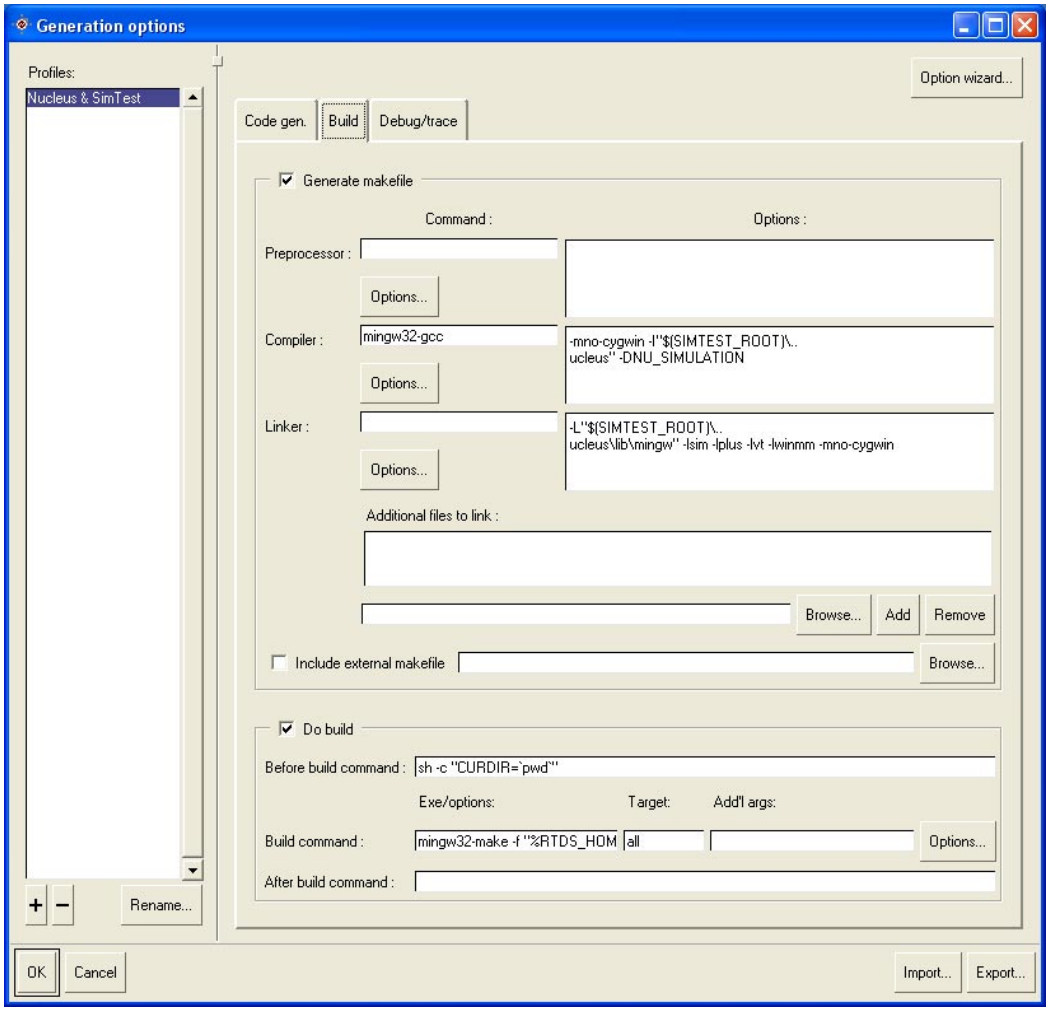
Real Timer Developer Studio includes a *Code template directory* to generate *Nucleus* applications and the SDL-RT debugger is interfaced with a special version of *gdb* provided by the EDGE environment tool and the SIMTEST tool. In the current release the *gdb* debugging profile is only supported on Windows.

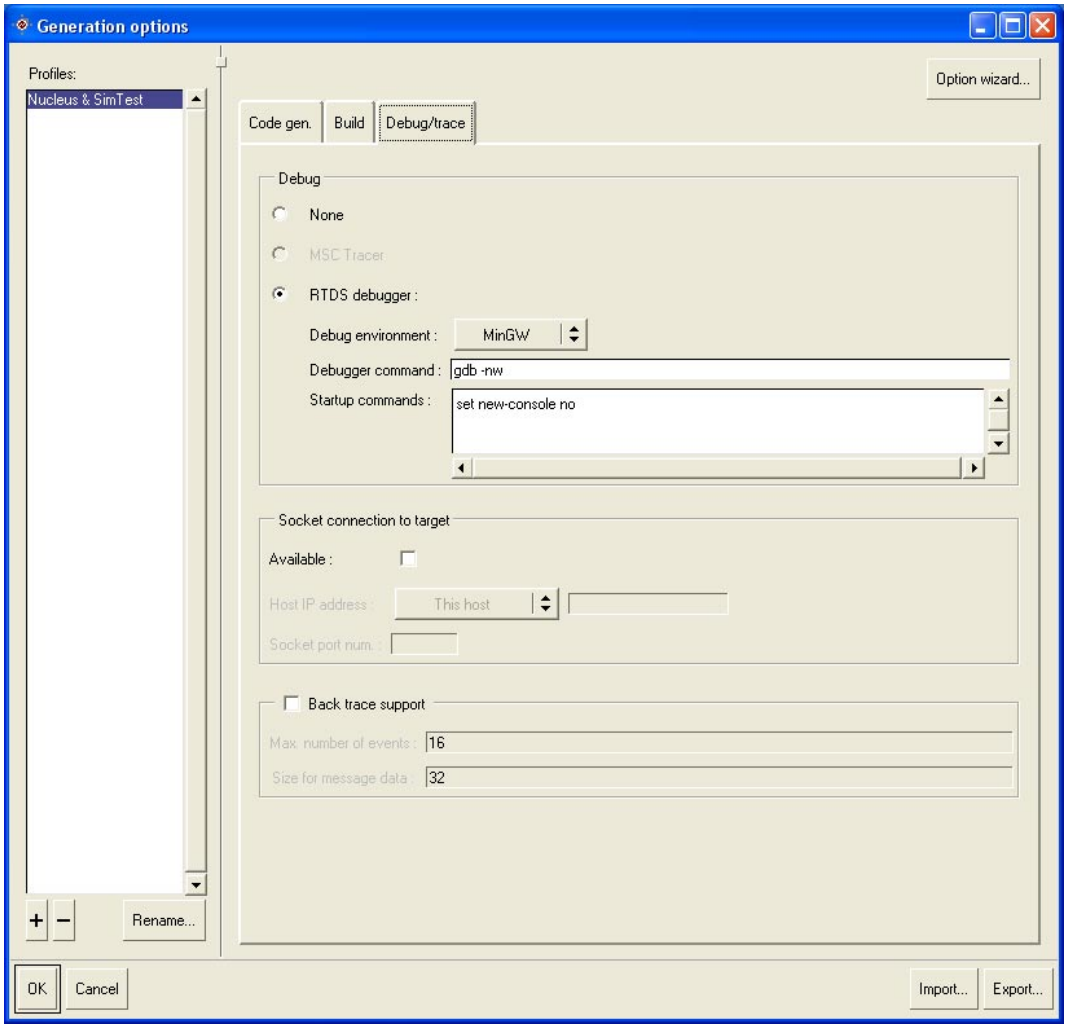
The profile characteristics are:

- Build process
  The Nucleus build process is based on `mingw32-make` utility. Note the Nucleus build process relies on the `SIMTEST_ROOT` environment variable which is defined by the simtest installer.
- SDL-RT system start
  The file `${RTDS_HOME}\share\ccg\nucleus\RTDS_OS.c` defines the function `Application_Initialize` that creates the `RTDS_Start` task that initialize RTDS environment and objects creation.
- Priorities
  SDL-RT process priorities are the ones of Nucleus. The default value is 125.
- Memory management
  RTDS generated code memory allocation `RTDS_MALLOC` and `RTDS_FREE` are based on `NU_Allocate_Memory` and `NU_Deallocate_Memory` Nucleus functions. The memory management is done by using a unique memory pool

Below is an Nucleus generation profile example with debug based on gdb:



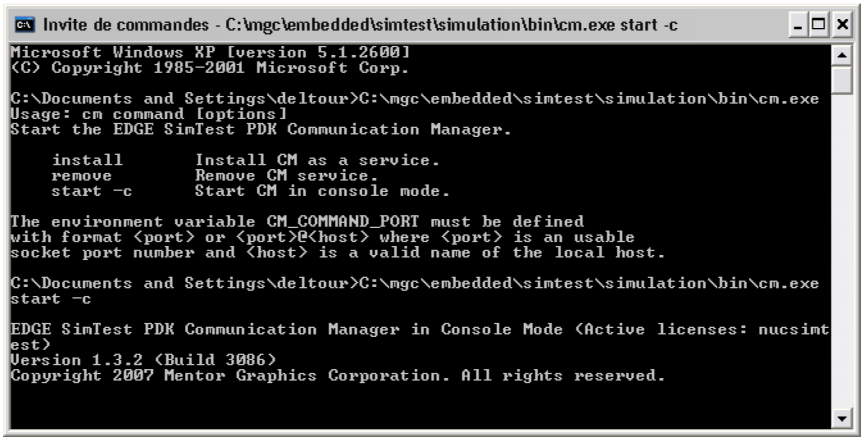




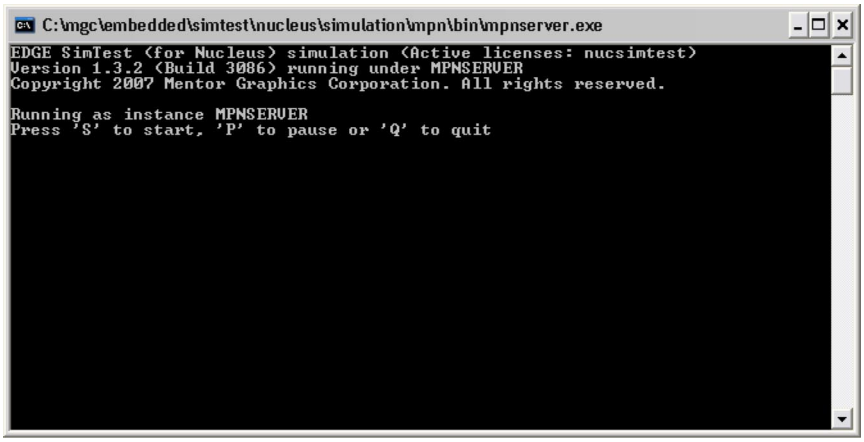
Typical generation profile to debug a Nucleus application with gdb

In order to debug a Nucleus application with SimTest kernel simulator, some manual operations are required:

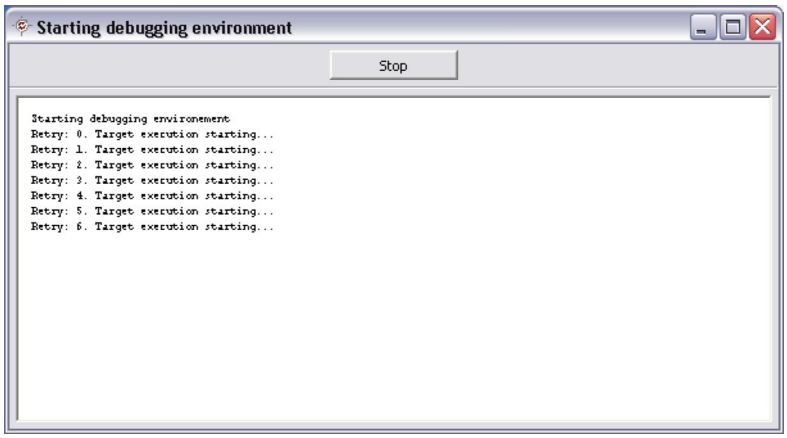
- Start the EDGE communication manager:
  `%SIMTEST_ROOT%\bin\cm.exe start -c`


Invite de commandes - C:\mgc\embedded\simtest\simulation\bin\cm.exe start -c
Microsoft Windows XP [version 5.1.2600]
(C) Copyright 1985-2001 Microsoft Corp.
C:\Documents and Settings\deltour>C:\mgc\embedded\simtest\simulation\bin\cm.exe
Usage: cm command [options]
Start the EDGE SimTest PDK Communication Manager.
install Install CM as a service.
remove Remove CM service.
start -c Start CM in console mode.
The environment variable CM_COMMAND_PORT must be defined
with format <port> or <port>@<host> where <port> is an usable
socket port number and <host> is a valid name of the local host.
C:\Documents and Settings\deltour>C:\mgc\embedded\simtest\simulation\bin\cm.exe
start -c
EDGE SimTest PDK Communication Manager in Console Mode (Active licenses: nucsimt
est)
Version 1.3.2 (Build 3086)
Copyright 2007 Mentor Graphics Corporation. All rights reserved.

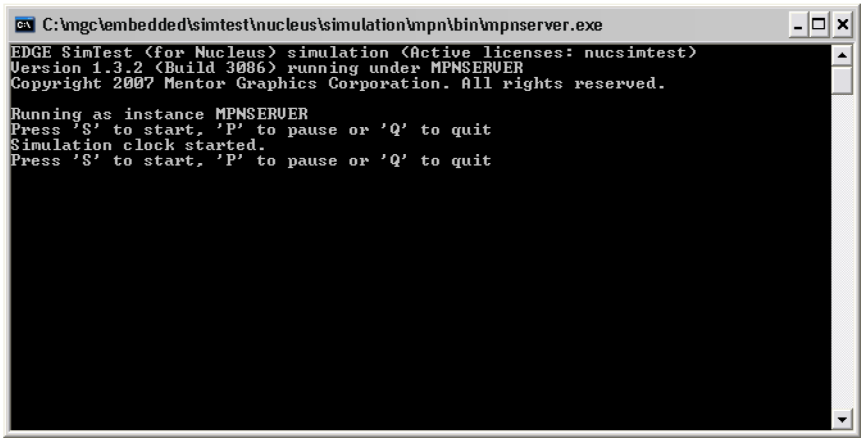
- Start the MPN server:
  `%SIMTEST_ROOT%\..\nucleus\simulation\mpn\bin\mpnserver.exe`


C:\mgc\embedded\simtest\nucleus\simulation\mpn\bin\mpnserver.exe
EDGE SimTest (for Nucleus) simulation (Active licenses: nucsimtest)
Version 1.3.2 (Build 3086) running under MPNSERVER
Copyright 2007 Mentor Graphics Corporation. All rights reserved.
Running as instance MPNSERVER
Press 'S' to start, 'P' to pause or 'Q' to quit

- Start RTDS debugger, when the debugger tries to connect to the executable:


Starting debugging environment
Stop
Starting debugging environement
Retry: 0. Target execution starting...
Retry: 1. Target execution starting...
Retry: 2. Target execution starting...
Retry: 3. Target execution starting...
Retry: 4. Target execution starting...
Retry: 5. Target execution starting...
Retry: 6. Target execution starting...

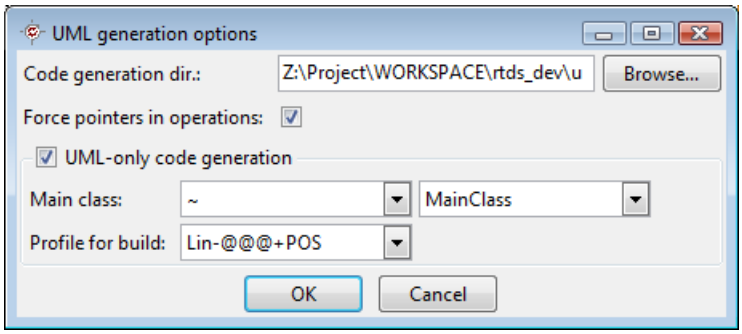
- Then type 'S' in the MPN server window:


C:\mgc\embedded\simtest\nucleus\simulation\mpn\bin\mpnserver.exe
EDGE SimTest (for Nucleus) simulation (Active licenses: nucsimtest)
Version 1.3.2 (Build 3086) running under MPNSERVER
Copyright 2007 Mentor Graphics Corporation. All rights reserved.
Running as instance MPNSERVER
Press 'S' to start, 'P' to pause or 'Q' to quit
Simulation clock started.
Press 'S' to start, 'P' to pause or 'Q' to quit

Then the debugger can connect to the target and you can debug normally.

5.3.3 UML options

There are specific options used when generating the C++ code for classes described in UML class diagrams. These options are set via the "UML options..." item in the "Generate" menu:



The available options are:

- The directory where the files for the UML classes must be generated;
- Wether parameters and return values in operations should be forced as pointers when their type is a user-defined class;
- Options for UML-only projects:
  - The main class for the application. This class will be automatically instantiated when the application starts. The equivalent of the C/C++ `main` function should be written in this class's constructor.
  - The profile used for generating the makefile and doing the build for the project.

For projects mixing SDL and UML, the generation directory for the passive classes should be different from the generation directory set in the profile for the following reasons:

- The generation directory set in the profile will contain the generated source files for all processes and blocks in the system. These files are just a result of the code generation: the real source code for the system is in the diagrams. So all files in this directory may be safely deleted;
- On the contrary, the class diagrams only describe the interface of the classes. The actual code implementing the operations are in the C++ source file. So this file must not be deleted, or actual code will be lost.

For this reason, RTDS uses a different policy for the two generation directories:

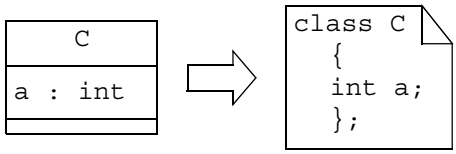
- In the generation directory set in the profile, if any generated source file needs updating because of changes in the corresponding diagram, it is always overwritten;
- In the UML generation directory, if a change was made in any diagram describing a class, the header file for the class is overwritten, but *not* the C++ file for the class, as it may contain actual code for the operations.
  However, added operations in the diagram will be added to the C++ source file, and warnings will be issued for each operation found in the file that is not in the diagrams. But nothing will ever be removed from the C++ source file.

5.3.4 Generated C++ code

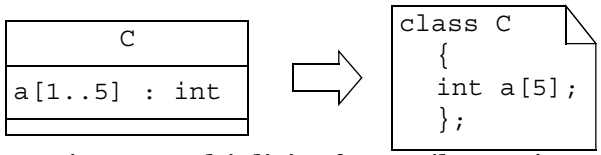
5.3.4.1 Attributes and operations

For any class involved in a code generation process, the following attributes and operations are generated in the class header file:

- For an attribute described as "*name* : *type*" (no multiplicity), an attribute with this name and type is generated.
  Example:

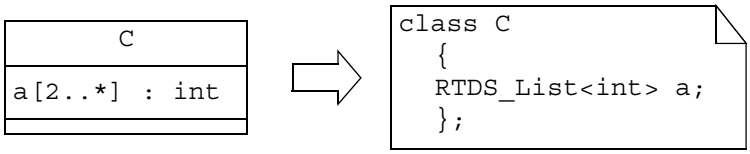


- For an attribute described as "*name*[*mult*] : *type*" with a finite multiplicity (no '*'), an attribute with this name and the type "*type*[*max*]" is generated, with *max* being the maximum multiplicity found in *mult*.
  Example:

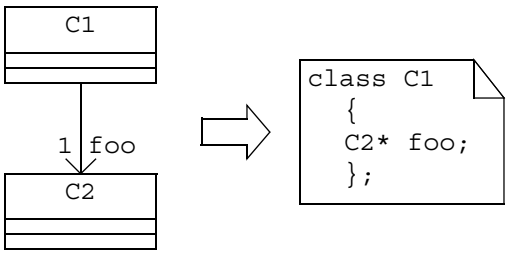


Maximum multiplicity for attribute a is 5
=> array of 5 ints

- For an attribute described as "*name*[*mult*] : *type*" with an infinite multiplicity ('*' somewhere in *mult*), an attribute with this name and the type "RTDS_List<*type*>" is generated (see notes below on page 177).
  Example:

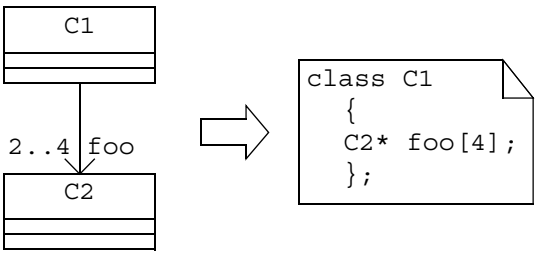


- For a navigable association to class *Class* with a cardinality of 1 or 0..1 and a role name *role*, an attribute named *role* with type *Class** is generated.
  Example:



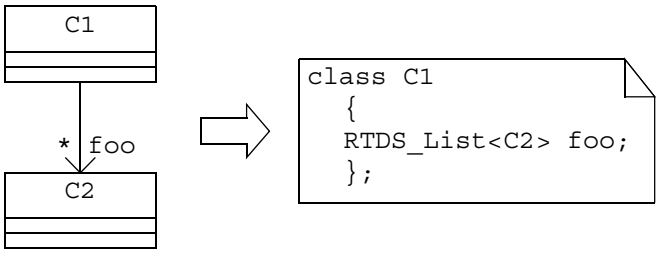
- For a navigable association to class *Class* with a multiple finite cardinality (not 1, not 0..1 and no '*' in cardinality) and a role name *role*, an attribute named

role with type *Class*`*` `[`*max*`]` is generated, where *max* is the maximum cardinality for the association.
Example:

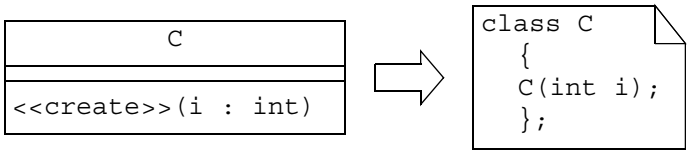


Maximum cardinality for association is 4 => array of 4 instances

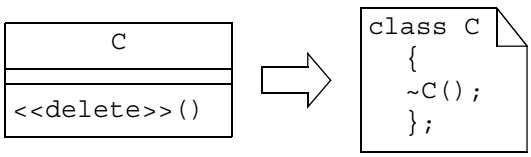
- For a navigable association to class *Class* with an infinite cardinality ('*' somewhere in cardinality) and a role name *role*, an attribute named *role* with type `RTDS_List<`*Class*`>` is generated (see notes below on page 177).
Example:



- For an operation named `<<create>>`, the corresponding C++ constructor is generated with the same parameters and no return type.
Example:

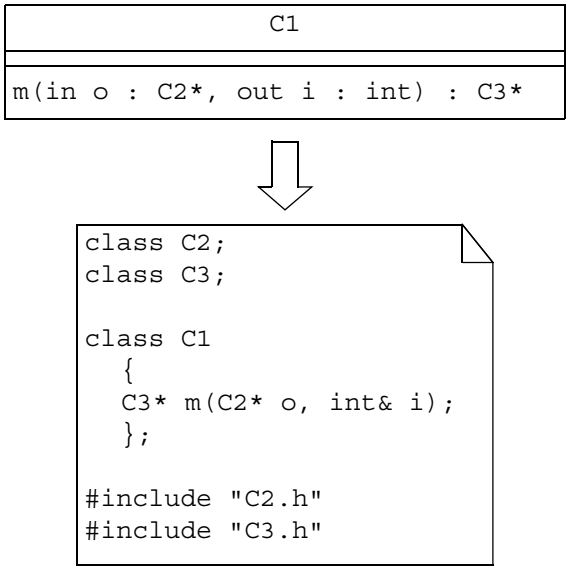


- For an operation named `<<delete>>`, the corresponding C++ destructor is generated with no return type. This operation must not have any parameters.
Example:



- For any other operation, the corresponding method is generated. A parameter declared as "`out` *name* `:` *type*" or "`inout` *name* `:` *type*" is generated with type *type*`&`. If a parameter type is an instance of a known class, it is recognized and

the corresponding declaration is included in the class header file. The same applies for the operation's return type.
Example:



If no C++ file for the class exists when the code generation is run, a basic C++ file containing a skeleton for the implementation of all known methods will also be generated.

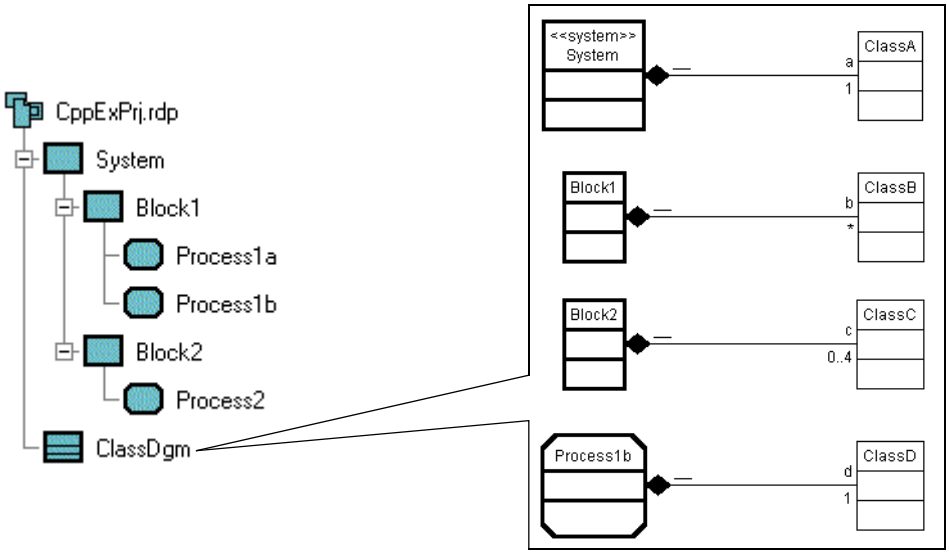
Notes:

- `RTDS_List` is a template class to manage lists of pointers. It is delivered with RTDS and located in directory `$RTDS_HOME/share/ccg/cpptemplates`. The parameter for the template is the type for the elements (e.g. `RTDS_List<int>` is a list of pointers to integers).
  Its public methods are:
  - `append` to add a new element at the end of the list. The only argument is a pointer to the element to add;
  - `del` to remove an element from the list. The argument is the index of the element to delete;
  - `length` returns the length of the list as an integer;
  - the operator `[]` is also redefined to give access to any element in the list by its index. The element can be accessed for reading (`eltPtr = list[index];`) and writing (`list[index] = eltPtr;`).
- No attribute should be declared with a type being a class defined in a diagram. If it is, the class won't be recognized and the class will be undeclared when it is used. To define such an attribute, it is mandatory to use an association.
- For attributes generated for associations, if the role name is not set or invalid, a modified version of the association's name will be used.

5.3.4.2 Declared variables

For any class involved in an association with a block or a process, the corresponding instances will be known to all elements in the block or process sub-tree.

For example:



The following variables are known:

- A variable named `a` with type `ClassA*` is known in all blocks and processes, since it's attached to the system itself;
- A variable named `b` with type `RTDS_List<ClassB>` is known in `Block1` and all its descendants, i.e. `Process1a` and `Process1b`;
- A variable named `c` with type `ClassC*[4]` is known in `Block2` and all its descendants, i.e. `Process2`;
- A variable named `d` with type `ClassD*` is known only in `Process1b`.

This is achieved by generating the following files:

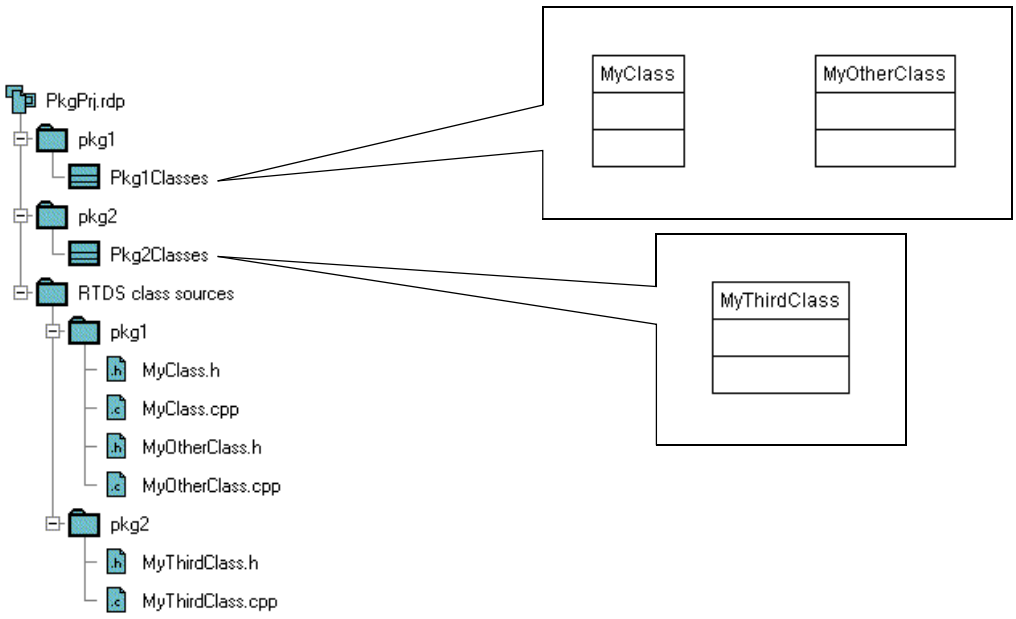
- For all associations attached to a system or block, a C file is generated for the system or block. It contains the declaration of all the variables as global. An `extern` declaration is generated in the system or block's header file, which is included in all descendants.
  In the example, variables `a`, `b` and `c` are declared as global, with their `extern` declarations inserted in `System.h`, `Block1.h` and `Block2.h` respectively.
- For all associations attached to a process, no additional file is generated. The variable is automatically declared as local in the function generated for the process.
  In the example, the variable `d` is declared as local to the function generated for process `Process1b` in `Process1b.c`.

5.3.4.3 Access to generated code

After a code generation, all generated code is made available in the project:

- The code for all processes and blocks is inserted in a package named "RTDS generated code";

- The code for all classes is inserted in a package named "RTDS class sources". The structure of this package is mapped to the package structure for classes. For example:



In "`RTDS class sources`":

- `MyClass.h`, `MyClass.cpp`, `MyOtherClass.h` and `MyOtherClass.cpp` are in sub-package `pkg1` because classes `MyClass` and `MyOtherClass` are in package `pkg1` in the diagrams
- `MyThirdClass.h` and `MyThirdClass.cpp` are in sub-package

5.3.5 Built in scheduler

The code generation described in “Code generation” on page 131 maps by default each SDL or SDL-RT process instance to a task in the target RTOS. RTDS also offers the possibility to execute several process instances in a single RTOS task. This allows for example to execute a whole block in a single task. If the whole system is executed in a single task, this even allows to execute it on a bare target without any RTOS. This feature is available for both SDL and SDL-RT projects.

When several processes are executed in a single task, no actual parallelism is involved: the instances are scheduled within the task, and transitions will be executed one at a time.

To turn process instance scheduling on, the following steps are required:

- Define which process instances will be scheduled and which ones will have their own RTOS task. This is done via a UML deployment diagram.
- Define a code generation profile that allows scheduling.
- Make sure the system is compatible with the scheduled mode. This mainly involves taking care about how semaphores are used in SDL-RT systems.
- For wholly scheduled systems without any RTOS, make sure messages coming from the environment and time will be handled correctly. This involves writing some external code.

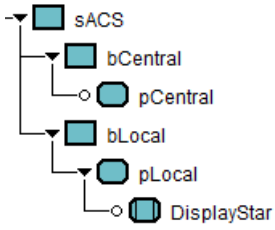
Generating scheduled code also allows integration in an external scheduler.

The following paragraphs describe these points in detail.

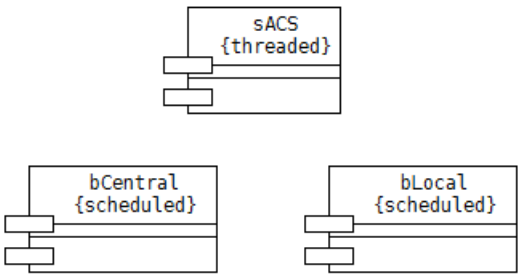
5.3.5.1 Deployment diagram for scheduling policy

To indicate which processes will have their instances scheduled and which will map to their own task, a UML deployment diagram has to be defined. In this diagram, agents will be represented as components, and the component properties will indicate if the agent is scheduled or threaded. The code generation should then be run on this diagram to actually turn scheduling on in the generated code.

For example, for a system with the following architecture:

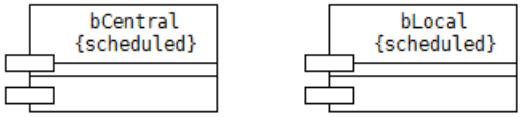


the components in the deployment diagram may be:

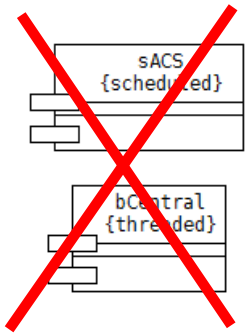


This means that all process instances within blocks `bCentral` will be scheduled together, as well as all process instances within `bLocal`. As the whole system is "threaded", a RTOS task will be created for each block `bCentral` and `bLocal`.

The default policy for agents is actually "threaded", so the diagram above is in fact equivalent to this one:

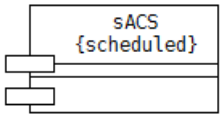


Of course, if an agent is scheduled, all the agents it contains will be scheduled too, so the following deployment diagram is illegal:



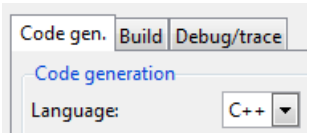
Forbidden

To schedule the whole system, allowing it to be executed without any RTOS, only the following component is necessary:



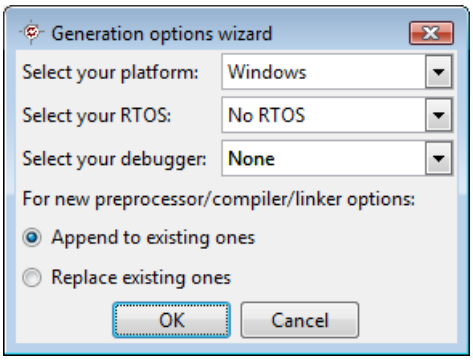
5.3.5.2 Profiles for scheduling

There is only one limitation on code generation profiles to make them compatible with scheduling: in SDL-RT projects, the profile must be set to generate C++ code in the "Code gen." tab, option "Language":



This limitation does not exist in SDL projects. However, if generating code for the C scheduler, object-oriented features such as process classes are not supported.

If the whole system is scheduled, a specific target can be used to generate code for a bare target without any RTOS. This can be chosen in the 'Option wizard' in the code generation options dialog:



Setting the RTOS to 'No RTOS' will use a specific integration in `<RTDS installation dir.>/share/ccg/rtosless` that does not require any service from the OS, except dynamic memory allocation.

When a code generation is run on a deployment diagram specifying scheduled agents, the files for the built-in scheduler will be automatically integrated in the generation and will appear in the "RTDS RTOS adaptation" folder. These files are not generated but included in the RTDS installation in the following directories:

- `<RTDS installation dir.>/share/ccg/cppscheduler` for files used in C++ code generation;
- `<RTDS installation dir.>/share/ccg/cscheduler` for files used in a C code generation (SDL projects only).

Generated code for scheduled processes will be very different from the generated code for threaded ones: each transition will be generated in its own function or method, allowing to call it from the scheduler itself. For more details, see RTDS Reference Manual.

5.3.5.3 Semaphore handling

In the context of a scheduler, everything that might interrupt a transition in the middle of its execution needs a special attention. In SDL, only procedure calls may interrupt the execution of a transition if the called procedure contains state changes. This case is handled in the generated code in a specific way (see RTDS Reference Manual).

In SDL-RT, in addition to procedure calls, transition execution may also be interrupted by semaphore takes. This case is much more difficult as several case may occur depending on the instance that takes the semaphore and the instance that already has already taken it:

- If each instance has its own task, the case can be handled as in normal code generation, i.e by using the semaphores provided by the RTOS;
- If the whole system is scheduled, it is possible to provide a specific implementation for semaphores that will handle the case (cf. RTDS Reference Manual);
- In all other cases, the problem is very difficult to solve. For example, if the instance holding the semaphore is in a task, but the instance taking it is scheduled with other instances in another task, a semaphore provided by the RTOS has to be used since there are two different tasks, but it will block not only the instance trying to take it, but all other instances in its task. A mutex semaphore

may also be very difficult to handle if it can be taken by instances scheduled in the same task or by instances in different tasks in the same system.

The solution chosen in RTDS is quite simple: except if the whole system is scheduled, RTDS will always use semaphores provided by the underlying RTOS. This means a system designed to work in threaded mode *may not work* if it's switched to partially scheduled mode if it handles semaphores. The architecture of the system and/or the way semaphores are used may have to be changed to get the system to work.

5.3.5.4 External messages and time management

Whenever an RTOS is used, external messages and time management are usually not a problem:

- External incoming messages are usually handled via interrupts, calling a routine that will build the message and put it in a message queue. Then the system resumes its normal execution.
- Timers are handled by system calls.

The case where the whole system is scheduled and no RTOS is used is more complicated to handle: external messages can be handled via interrupts, but the instance expecting them can't be simply waiting on a message queue and woken up automatically when it arrives. The instance will be scheduled and there must be a way to inform the scheduler that a message has arrived. As for timers, since there is no RTOS, there is available system call to handle time.

In this case, the handling of time is done via 2 specific functions, called `RTDS_incomingSdlEvent` and `RTDS_SystemTick`:

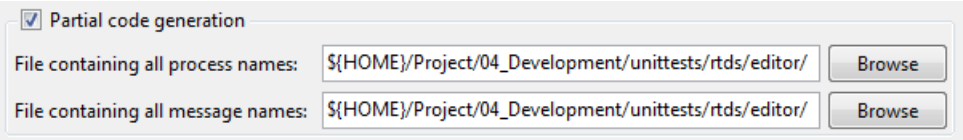
- `RTDS_incomingSdlEvent` is called automatically by the scheduler whenever there is no internal message to handle. It should be written by the user. Its parameters are a preallocated message header structure for the received message if any, and the time left until the next timer should fire. This function should wait for an incoming message, at most for the time passed as parameter, and then return to the caller. It returns a boolean which should be true if a message has been received, or false if the reception timed-out.
- `RTDS_SystemTick` increases the system time by one tick and updates the list of running timers to decrease the delay before they should time-out. This routine is provided by RTDS, but should be called by user-code, for example on a cyclic interrupt used to handle time.

A default implementation for `RTDS_incomingSdlEvent` is provided by RTDS if the macro `RTDS_HANDLE_EXTERNAL_EVENTS` is defined in the compilation options. This default implementation just calls `RTDS_SystemTick` and returns false to indicate no external message has arrived. This default implementation just ensures that systems will work in the RTDS debugger without writing any additional code. It should obviously not be used in real systems.

5.3.5.5 Integration in external scheduler

It is possible to generate code for a set of processes that will be used in an external scheduler, different from the RTDS built-in one. To do this, a special code generation profile

should be created with the option 'Partial code generation' turned on (in the 'Code gen.' tab):



If this option is turned on, the generated code will basically contain only the source and header files generated for the processes themselves, with only a few additional global header files. No entry point and no makefile will be generated. Note that this feature is only available when the target language is C. Partial code generation in C++ is not supported yet.

Since RTDS code generation requires to know the existing processes and the existing messages to generate some global constants and types correctly, two files must be specified when partial code generation is on:

- The 'File containing all process names' entry should reference a file containing the names for all *RTDS* processes that will be integrated in the final build. The names should be specified one per line and are case-sensitive. This information is used to generate the structures holding the instances local variables.
- The 'File containing all message names' entry should reference a file containing the names of all incoming and outgoing messages for all *RTDS* processes. The names should also be specified one per line and are also case-sensitive. This information is used to generate the transport structures for messages and the macros handling them.

Please note these two files must only include processes and messages handled in RTDS. If another process or message is inserted here, the generated code may use a type or constant that won't be defined and may fail to compile.

More details about the generated code and how it can be integrated in an external scheduler is given in RTDS reference manual. An example is also available in RTDS distribution, showing how results of different partial code generations can be integrated together. This example is located in `<RTDS installation dir.>/examples/SDL/PartialCodeGen-ADVANCED`.

5.4 - Good coding practise

5.4.1 Memory allocation

Memory allocation has to be handled very carefully in real time systems since it can generate memory leaks leading to system crashes that can be very difficult to debug. Considering Real Time Developer Studio is hiding the basics of the finite state machines it is important to point out what should be done in the code to have things work properly.

First of all when SDL messages are sent, received or saved, or when timers are set or reset, the generated code will handle memory allocation and de-allocation automatically so that the user does not have to deal with it. On the other hand, when user data is transmitted in a message from a process to another one, it is very important to define which process has the responsibility to free the corresponding memory. We strongly suggest the sender process always allocates the necessary memory and the receiver process always frees. It implies the sender process should not deal with the data any more after it has been sent. A good way to do so is to set the corresponding pointer to `NULL` after it has been sent out.

5.4.2 Shared memory

It is very common to use global variables or shared memory areas to exchange information between tasks. It is also very dangerous because two tasks could access the same information at the "same time" and read or write inconsistent information.

The same problem exists when using an instance of a class attached to a block or the whole system: all tasks know this instance, and can access its attributes or call its methods, leading to the same concurrency problems than for a global variable.

To avoid such problems we suggest to use a semaphore. Whenever a task needs to write or read a shared memory area, or to access an attribute or call a method on a shared object, it takes the semaphore. When the task is done, it gives it back to the system allowing another task to access the memory or the object. It is very important to do so even when reading memory or attributes since the reading task could be interrupted by a writing task. In that case the information read would be inconsistent.

5.4.3 RTDS macros and functions

As explained in this user's manual the code generator is based on C macros and C functions. Since these macros and functions are explained and delivered as source code it is very tempting to use them directly in C or to modify their source code.

It is important to realize these macros and functions have been designed to work with the generated code. They very often rely on the code generator to generate some complementary code to create a consistent behavior. They have also been deeply tested to guarantee safe code generation.

Before using these directly or trying to modify them it is important to deeply study and understand the delivered files to measure the impact of any modification. It is also very important to test any modification.

Furthermore the use of these macros and functions will make the design less legible where it is one of the key features of the tool.

5.5 - SDL-RT debugger

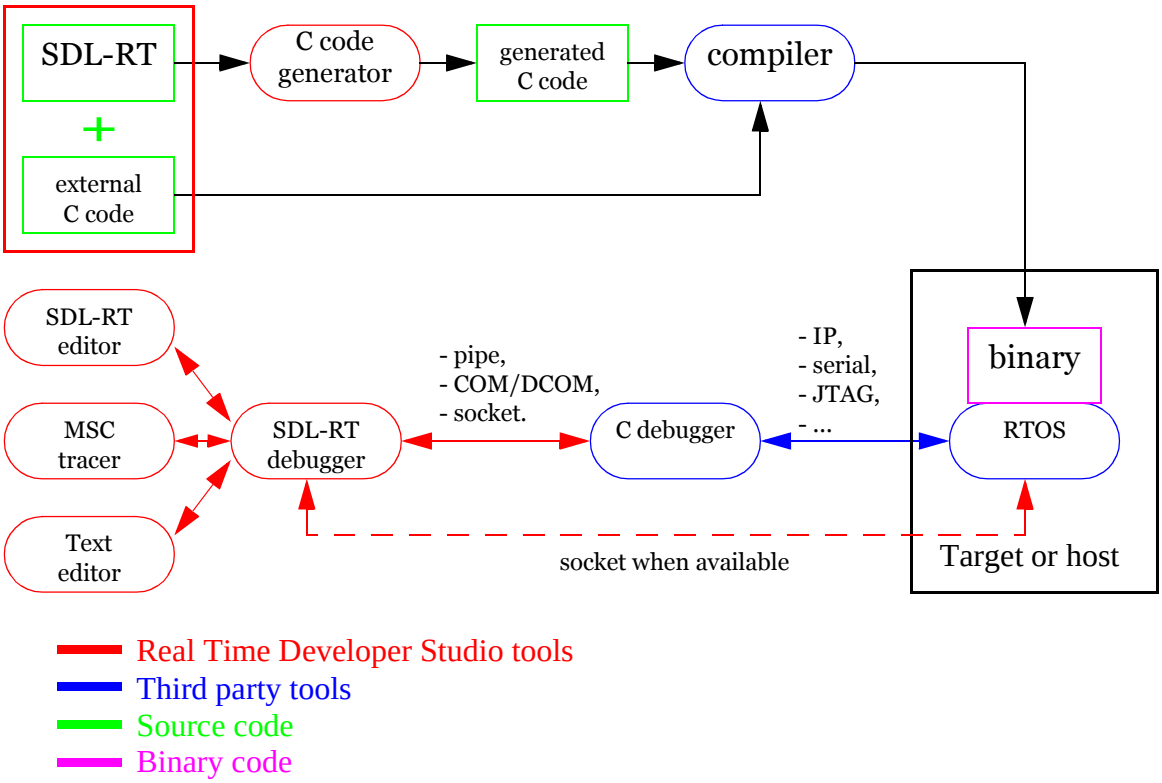
The SDL-RT debugger relies on classical C debuggers or cross debuggers to allow graphical debugging and SDL-RT oriented information.

Currently supported debuggers are:

- Tornado
- gdb
- MinGW
- Tasking Cross View Pro C166/ST10
- XRAY
- Multi 2000

5.5.1 Tool architecture

The *SDL-RT debugger* allows you to execute your SDL-RT system and the associated C code. To do so *Real Time Developer Studio* generates the code necessary to execute the SDL-RT processes on host or target and interfaces with a debugger or a cross debugger.



The *SDL-RT debugger* has all the expected features of a debugger. It allows you to:

- Graphically trace the internal behavior of the system
- Graphically step in the SDL or C source code
- Visualize all key internals of your system such as:
  - Tasks,
  - Semaphores,
  - Timers,

  - Local variables in the current frame,
  - Global variables.
- Send SDL messages to your system,
- Modify SDL state,
- Modify variables value.

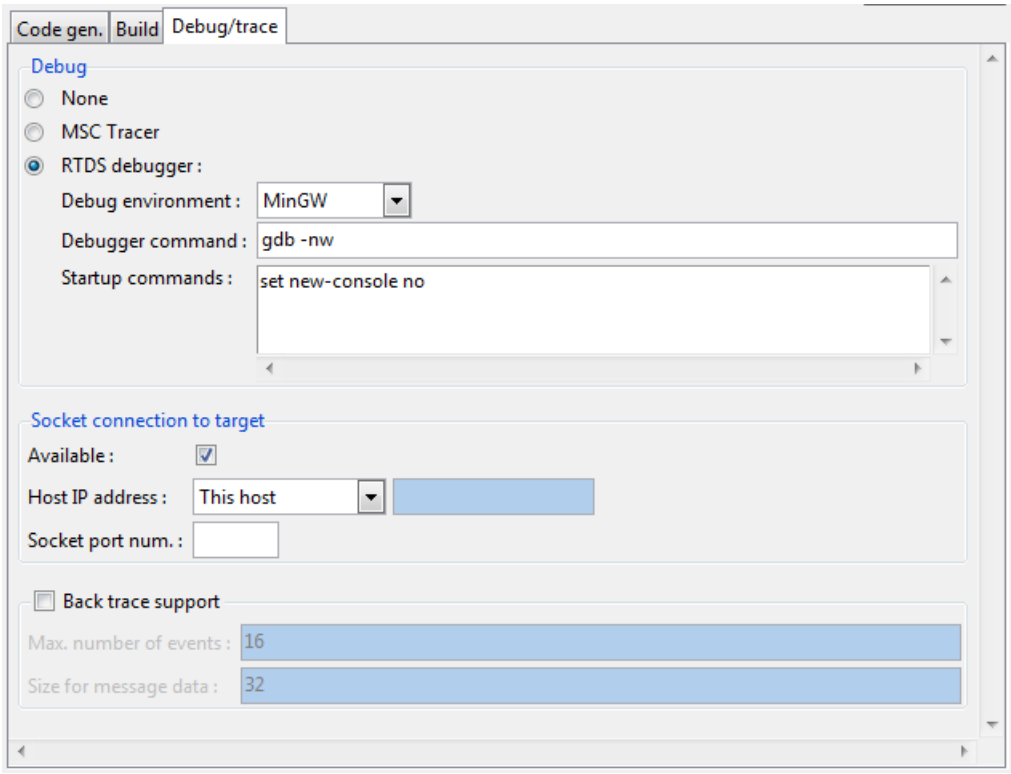
5.5.2 Launching the SDL-RT debugger

Before starting the SDL-RT debugger the generation profile should be verified. Graphical debugging has a specific profile since it will:

- automatically define some compiler options such as `-g` and `-DRTDS_SIMULATOR` that are defined in the `DefaultOptions.ini` file in the `$(RTDS_HOME)/share/ccg/<RTOS>` directory,
- launch the debugger automatically.

A generation profile is considered an SDL-RT debug profile as soon as *RTDS debugger* is selected in the *Debug* section in the *Debug / trace* tab.

Generation profiles are edited from *Generate / Options* menu. A typical SDL-RT debugging profile would look like this:

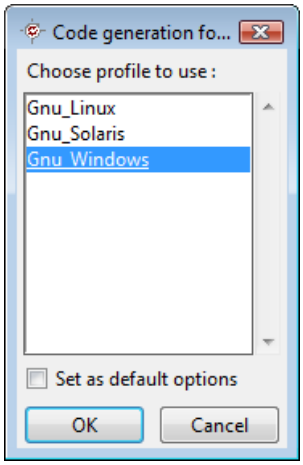


Once the code generation profile is selected the tool will:

- Check syntax and semantic of the SDL-RT system,
- Generate the C code,
- Compile and link the C code,
- Start the selected debugger environment,
- Load the executable,
- Start the executable with a breakpoint on it so it will stop on RTDS_Start function.

The *SDL-RT debugger* is started from the *Project manager Generate / Simulate* menu or from the quick button.

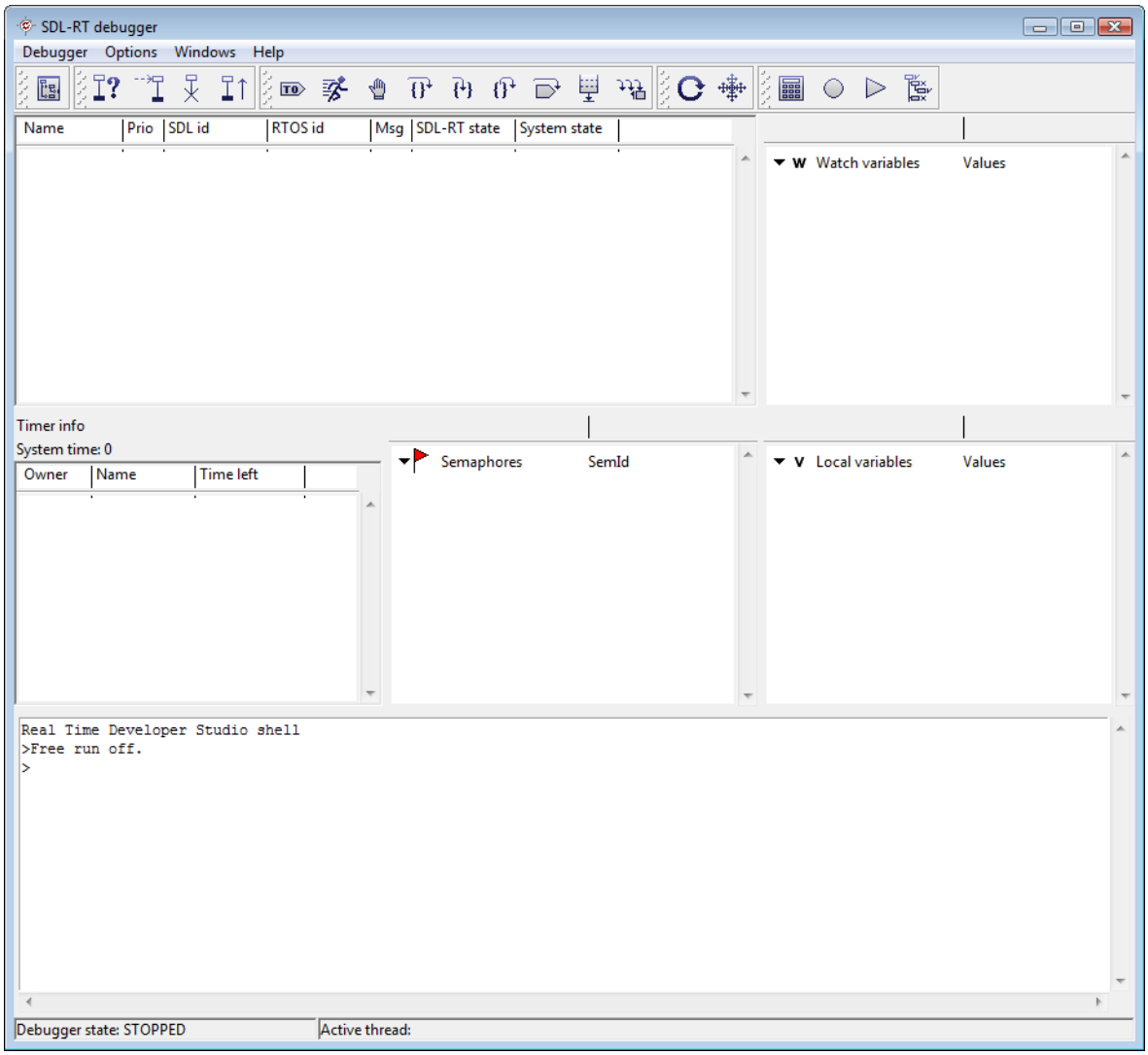
If several debug profiles are available a pop-up window will ask to select the desired profile:



When always using the same profile it is possible to set a default profile to launch so that the selection window does not pop up.

Syntactic check, semantic check, code generation, and compilation are done. The selected debugging environment is started with the *Debugger command* defined in the

Generation profile. The *SDL-RT debugger* window is started automatically and you are ready to debug your system !



The SDL-RT debugger window

The SDL-RT debugger can be restarted at any time with the reset button or shell command. The underlying C debugger is restarted and the executable is reloaded so that the environment is cleaned up.

5.5.3 Stepping levels

Since your source code is a composite of SDL and C and considering some code has also be generated by the code generator, the *SDL-RT debugger* offers several ways to execute the code:

- Run with SDL key events trace information,

  Menu *Options / Free run* de-activated. This is the default setup where the SDL-RT debugger traces all SDL key events and displays textual and / or SDL and / or MSC traces.
- Run without SDL key events trace information,

Menu *Options / Free run* activated. The tracing mechanism uses a breakpoint on RTDS_DummyTraceFunction in the generated C code. When this option is activated the breakpoint is removed and the system runs freely. Of course no trace information is available then.

- Stop execution,

  Stops execution of the running system.

- C step mode
  Menu *Options / SDL step mode* de-activated. This is the default C debuger behavior where the SDL-RT debugger steps every line of C code wether it is generated or not.

  Step line by line in any C code,

  Step-out a C function,

  Step-in a C function.

- SDL-RT automatic stepping,

  Steps automatically at C level until it reaches a generated C line corresponding to an SDL-RT graphical source code symbol. Note it might generate a lot of C steps and the expected result depends on the underlying debugger and RTOS integration. For example with gdb and windows integration it will step in the same task and let the other tasks run. But with Tasking and CMX it will step from one task to the other following the RTOS scheduling mechanism.
- Step until the next SDL key event such as:

  - Message sending,
  - Message received,
  - Timer started,
  - Timer cancelled,
  - Timer went off,
  - Semaphore take attempt,
  - Semaphore take succeeded,
  - Semaphore give,
  - SDL state modification,
  - SDL process created,
  - SDL process deleted.

  For your information these key events are traced via a breakpoint on an empty C function called `RTDS_DummyTraceFunction()`. So do not be surprised if you end up in this empty function; it is normal...
- Run until RTOS message queue is empty

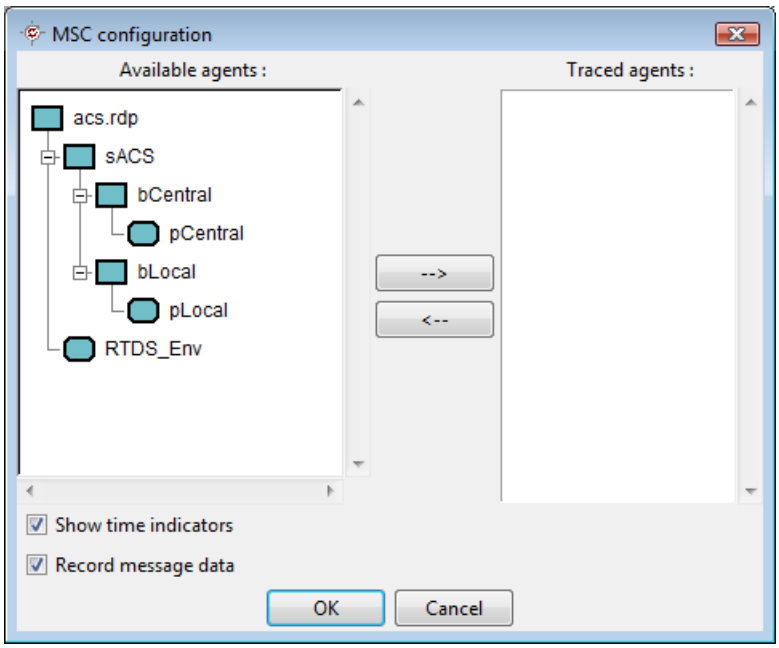
This will run the system until one of the external message queue is empty. When using RTDS scheduler, the scheduler internal queue is read until it is empty before the external queue is read. If the whole system is scheduled this feature can be used as a run until timer.

5.5.4 MSC trace

The MSC tracer allows you to graphically trace execution of the system with its SDL key events. It is possible to configure the MSC trace to define at which level of details the architecture of the system should be represented. The MSC trace can be made at system, block, process or any combination of agents. Any agent selected will be represented by a lifeline in the MSC diagram. Any messages exchanged inside the agent will not be seen on the MSC. The default view is the most detailed one, with a lifeline for each process.

- Configure the MSC trace

  The quick button opens the MSC trace configuration window:



  The following options are available:
  - Show system time information,
  - Record and display message parameters,
  - SDL-RT architecture elements to trace.
- Start the MSC trace
  - The quick button starts the *MSC Tracer*. By default the trace is active.
- Stop the MSC trace
  - The quick button stops the *MSC Tracer*.

- Trace the last SDL-RT events (backTrace)
  - The quick button opens an *MSC Tracer* and displays the last SDL-RT events. The number of events traced are configured in the generation options.

5.5.5 Displayed information

The *SDL-RT debugger* window is divided in 5 parts described below. Each time an SDL key event is received all the information is updated.

If needed the displays can be refreshed at any time with the `refresh` button or shell command.

The information to refresh can be setup in the *Options / Refresh options...* menu as explained in “Refresh options” on page 197.

5.5.5.1 Processes

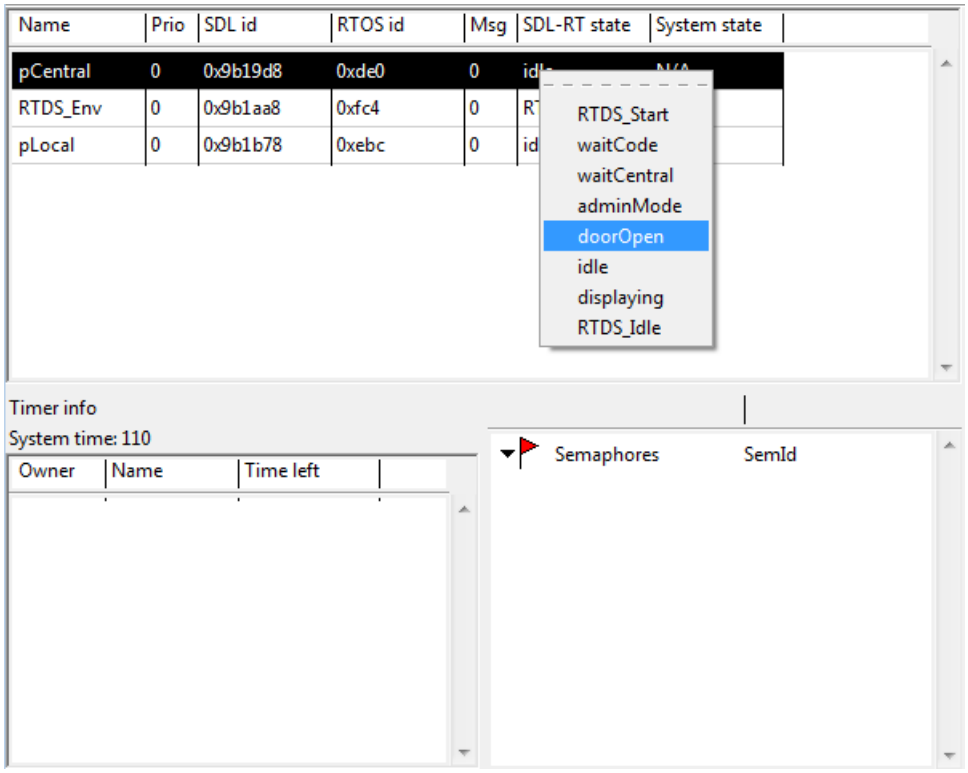
The *Process information* part list all processes defined in the SDL-RT system. It will not list any other processes running on the RTOS. The displayed information is:

- Name
  This field displays the name of the process as defined in the Process create SDL symbol. Several tasks can have the same name. The SDL id should then be used to distinguish them. When using the SDL output TO_NAME symbol it will search for the value of that field on the target to find the receiver.
- Prio
  This field displays the priority of the task as defined in SDL process create symbol. The value is expressed in decimal. This value is not available on all integrations.
- RTOS id
  This field shows the Process Identifier of the task as defined by the RTOS. As several processes can be run within the same RTOS task with the RTDS scheduler, please note several processes can have the RTOS id.
- SDL id
  This field is a unique identifier of the running process.
- Msg
  This field shows the number of messages waiting in the task’s queue. It does not include saved messages.
- SDL state
  This field is the internal SDL state of the SDL process as defined in the SDL diagram.
- System state
  This field is the task state from the RTOS point of view. Typically if a process is hanging on its queue or a semaphore it is in the `PEND` state. If the task is running it is in the `READY` state. This information is not available on all integrations.

When the system is running the active process line is printed in red.

The *SDL-RT debugger Process information* window also allows to modify the SDL-RT state of a process. To do so right click on the SDL state column of the process line. A pop

up menu will list all the available SDL state that have been defined in the system. Select one and the SDL state is modified.



SDL-RT state modification example

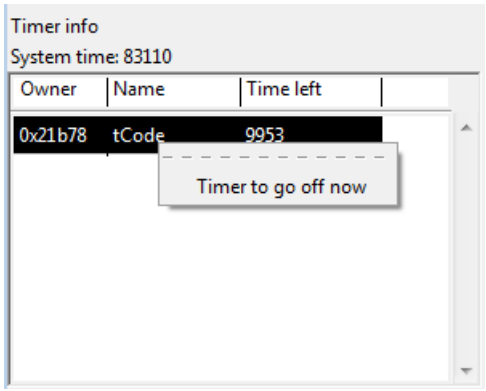
5.5.5.2 Timers

The *Timer info* part displays all on-going timers started from the SDL-RT design. The displayed fields are:

- Name
  Name of the timer as defined in the SDL-RT design.
- Pid
  Identifier of the task that started the timer.
- Time left
  Time left before the timer goes off. The display is updated when an SDL key event occur so the value displayed here is the time left when the last SDL key event occurred.

With windows and posix integrations it is possible to simulate discrete time. To do so `RTDS_DISCRETE_TIME` must be defined in the compiler options. In that configuration

time will never increase until the user fires a timer. To make a timer go off, right click on the timer's name.



Example: have tCode to go off

5.5.5.3 Semaphores

The semaphore tree lists all semaphore declared in the SDL-RT system and their address. When expanded it shows the current state, type and options of the semaphore. If processes are blocked on the semaphore they will all be listed after the information line.

It is important to understand how the trace works with semaphore in order to understand that what you see might not be what is really happening on the target. When taking a semaphore the SDL-RT debugger distinguishes two key events: an attempt to take the semaphore and a successfully taken semaphore. If the second key event is not seen, the semaphore tree is not updated but it might be because the semaphore is blocked on it. The information will be displayed at the next SDL key event; not before. Let's take an example to make it clear: process P1 has taken semaphore S1 and process P2 makes an attempt to take S1. The *SDL-RT debugger* trace will display:

```
Semaphore: S1(0x4b3eeb8) take attempt by: P2 at: 0x73d ticks
```

P2 will get blocked on S1 and if there is no SDL key event happening the semaphore tree will not be refreshed and display no blocked process on S1... In such a case you should use the *refresh* button to update the tree.

5.5.5.4 Watch

There are several ways to add a variable in the *SDL-RT debugger Watch window*:

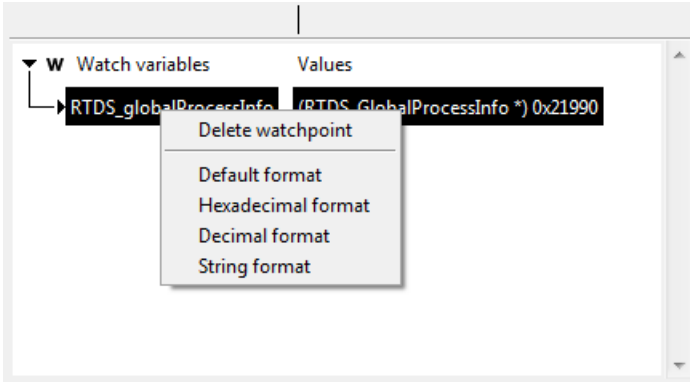
- From the shell
  Type the following command in the shell:
  `watch add <variable name>`
- From the text editor when the SDL-RT debugger window is open
  Select an expression in the editor and go to the *Debug / Watch* menu to add the expression in the *SDL-RT debugger Watch Window*.
- From the SDL-RT editor
  Select an expression in the SDL-RT editor and go to the *Debug / Watch* menu to add the expression in the *SDL-RT debugger Watch Window*.

Variables can be removed from the *SDL-RT debugger Watch window:*

- from the shell with the following command:

`watch del <variable name>`

- from the *SDL-RT debugger Watch window* with right mouse button as shown below:

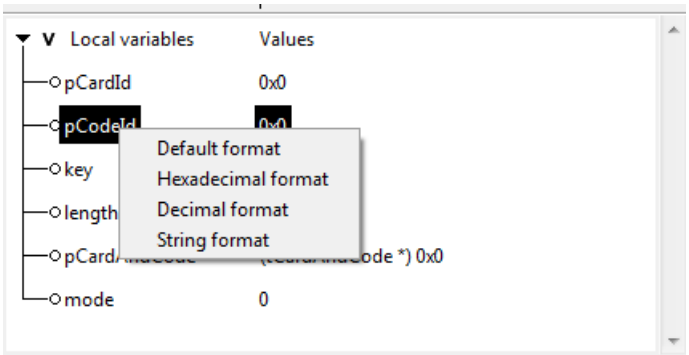


The *SDL-RT debugger Watch window* also allows to modify the value of variables. To do so double click on the value of the variable to be modified. Press `<Return>` and the value is updated.

5.5.5.5 Local variables

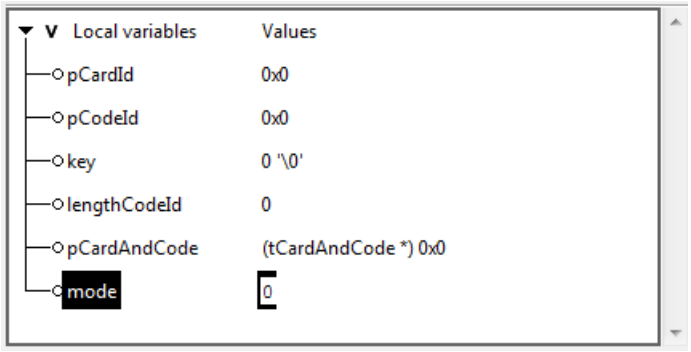
When stepping through the code the *SDL-RT debugger* automatically displays the local variables of the current stack frame. That gathers all local variables of the current C function including the arguments of the function. Nothing has to be done to update the SDL-RT debugger Local variable window.

Depending on the type of the variable the best display format is automatically selected but it is possible to select a specific format to display a value. To do so, right click on the variable and the following pop up menu will be displayed:



When stepping in the generated C code the current stack frame contains local variables used by *Real Time Developer Studio* to handle internal information. All these variables name start with `RTDS_` so that there is no confusion with any other variable. Since the SDL-RT debugger is designed to debug the SDL-RT system these variables are hidden from the *SDL-RT debugger Local variables* window. But it is possible to display them with the *Option / Show internals* menu.

The *SDL-RT debugger Local variables* window also allows to modify the value of variables. To do so double click on the variable to edit the value. Press `<Return>` and the value is updated.



Setting a local variable value example

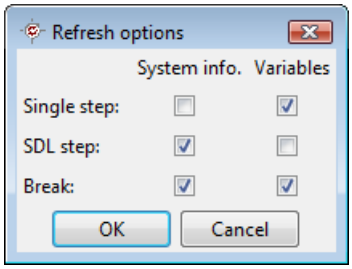
5.5.5.6 Refresh options

The information displayed in the SDL-RT debugger windows are divided in 2 categories:

- System info
  - Process information
  - Timer information
  - Semaphore information
- Variables
  - Local variables
  - Watch variables

Retrieving any information from the target is time consuming. In order to optimize the response time it is possible to configure which category of information is refreshed.

The configuration is done in the *Options / Refresh options...* menu.



Default Refresh options

- C step means the use of one of the following step button: ,
  In the default options, only the Variables category is refreshed since there is no reason the System information category has changed in the meantime.
- SDL step means the use of step button,
  When stepping from an SDL event to another, only the System information category is interesting to update.
- Break means the system has hit a breakpoint.
  In that case it is recommended to update all the information.

Anyway, at any time it is possible to refresh all information :

Note signals (SIGINT, SIGSEV...) will be reported in the SDL-RT debugger but no refresh action is done.

5.5.6 Shell

The SDL-RT debugger shell allows to enter all commands listed above and is used as a textual trace.

The available commands are grouped in categories. To list all the available categories type:

`help`

It will list the following categories:

```
Type help followed by a category to list available commands
-----------------------------------------------------------
  shell
  execution
  interaction
  variables
  trace
  customization
```

Type help followed by a category name to list the corresponding commands.

To list all the available commands, type:

`h`

It will list the following commands:

```
Command       - Explanation
-----------------------------
h             - lists all commands
history       - list the last entered valid commands
clear         - clears the shell
echo <string> - echos a string in the shell
include <file name>
resume        - resumes the scenario
repeat <repeat count> <shell command> [|; <shell command>]*
# <comment>
! <any host command>
refresh            - refreshes all data in the window
run                - runs the SDL system
stop               - stops the SDL system
step               - step in the code
stepin             - step in function calls
```

```
stepout             - step out a function call
keySdlStep          - run until the next key SDL event
sdlTransition       - run until the end of the SDL transition
runUntilTimer       - run all transitions until timers
runUntilQueueEmpty - run all transitions until RTOS queue is empty
list                - list breakpoints
watch add [<pid>:]<variable name>[<field separator><field name>]*
watch del [<pid>:]<variable name>[<field separator><field name>]*
break <break condition> [<ignoreCount> <volatile>]
delete <breakPoint number>
db <any debugger command>
set time <new time value>
send2name <sender name> <receiver name> <signal number or name> [<parameters>]
send2pid <sender pid> <receiver pid> <signal number or name> [<parameters>]
sendVia <sender pid> <channel or gate name> <signal number or name> [<parameters>]
send <sender pid> <signal number or name> [<parameters>]
systemQueueSetNextReceiverName <receiver name>
systemQueueSetNextReceiverId <receiver id>
extractCoverage <file name>
connect <port number>
connectxml <port number>
disconnect
varFromType <variable name> <variable type>
varFromValue <variable name> = <initial value>
varFieldSet <variable name>[.<field name>]* = <field value>
dataTypes <on | off>
print <variable name>
sdlVarSet [-x] [<process id>:]<sdl variable name>=<value>
sdlVarGet [-x] [<process id>:]<sdl variable name>
backTrace     - display last events traced when activated in profile
setupMscTrace <time information> <message parameters> [<agents>]
startMscTrace
stopMscTrace
saveMscTrace <file name>
setEnvInterfaceFilter 1|0
buttonWindowCreate <button window name>
buttonWindowAdd <button window name> <button name> = <shell command> [|; <shell command>]*
buttonWindowDel <button window name> <button name>
buttonWindowLabelAdd <button window name> <label name>
buttonWindowLabelDel <button window name> <label name>
startPrototypingGui
-----------------------------
In any of the shell commands the following can be used:
```

```
|$(<os environment variable>) to acces an operating system environment variable
|${<interactive label>} pops up an interactive window to get variable value, /s, /b and others can be used
|$[<shell variable name>] will be replaced by the shell variable value
|$<<process name>:<instance number>> will be replaced by the pid of the instance of the process
& <any command> will prevent the above pre-processing
<partial command>\ and continue the command on the next line of the shell
```

The last valid commands can be recalled with the upper arrow.

Some of these commands are the equivalent to buttons in the button bar. Some are specific to the shell and will befurther explained below.

5.5.6.1 shell commands

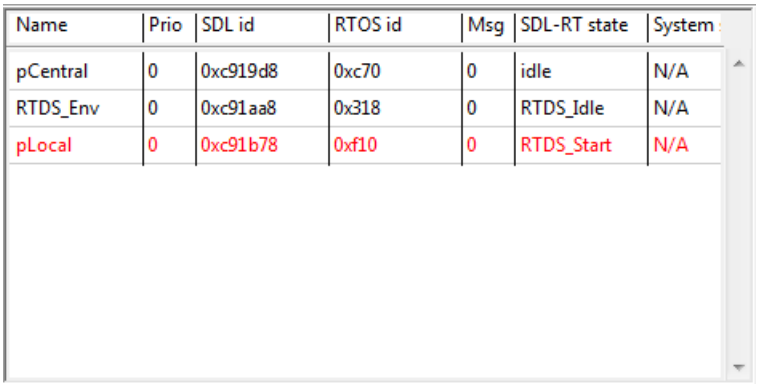
To list all the available commands in this category, type:
`help shell`

It will list the following commands:

```
Command       - Explanation
---------------------------
h             - lists all commands
history       - list the last entered valid commands
clear         - clears the shell
echo <string> - echos a string in the shell
include <file name>
  run a scenario of commands out of a file
resume        - resumes the scenario
repeat <repeat count> <shell command> [|; <shell command>]*
  repeat a set of shell commands
# <comment>
  does nothing
! <any host command>
  runs any host command
-----------------------------
In any of the shell commands the following can be used:
|$(<os environment variable>) to acces an operating system environment variable
|${<interactive label>} pops up an interactive window to get variable value, /s, /b and others can be used
|$[<shell variable name>] will be replaced by the shell variable value
|$<<process name>:<instance number>> will be replaced by the pid of the instance of the process
& <any command> will prevent the above pre-processing
<partial command>\ and continue the command on the next line of the shell
```

- Running scenarios
  A set of commands can be saved to a script file with the red circle button in the tool bar. The include command or the play button allows to run a script file. The script file is stopped when a breakpoint is hit or when the stop button is pressed. Type the resume command to resume the scenario.

- Process instances pid
  It is possible to get a process instance pid with the `|$< <process name> >` syntax.
  Example:
  In the following configuration:



Name	Prio	SDL id	RTOS id	Msg	SDL-RT state	System
pCentral	0	0xc919d8	0xc70	0	idle	N/A
RTDS_Env	0	0xc91aa8	0x318	0	RTDS_Idle	N/A
pLocal	0	0xc91b78	0xf10	0	RTDS_Start	N/A

  `echo |$<pCentral:0>`
  echos the pid (SDL id) of the first instance of `pCentral`:
  `0xc919d8`
  Note:
  This feature does not work if the *Free run* option is activated.
- Environment variables
  Operating system environment variables can be accessed with the `|$(<variable name>)` syntax.
  Example:
  `echo |$(RTDS_HOME)`
  echos:
  `C:\RTDS`

5.5.6.2 execution commands

To list all the available commands in this category, type:
`help execution`

It will list the following commands:

```
Command       - Explanation
---------------------------
refresh            - refreshes all data in the window
run                - runs the SDL system
stop               - stops the SDL system
step               - step in the code
stepin             - step in function calls
stepout            - step out a function call
keySdlStep         - run until the next key SDL event
sdlTransition      - run until the end of the SDL transition
runUntilTimer      - run all transitions until timers
runUntilQueueEmpty - run all transitions until RTOS queue is empty
list               - list breakpoints
```

```
startPrototypingGui
watch add [<pid>:]<variable name>[<field separator><field name>]*
  adds a variable to watch:
  <pid> is the process id in which the variable is. Only available in Z.100 simulation.
  <variable name> is the name of the variable
  <field separator> is '!' in SDL Z.100 or '.' in SDL-RT
  <field name> is the name of the variable field or sub-field
watch del [<pid>:]<variable name>[<field separator><field name>]*
  remove a variable to watch
  <pid> is the process id in which the variable is. Only available in Z.100 simulation.
  <variable name> is the name of the variable
  <field separator> is '!' in SDL Z.100 or '.' in SDL-RT
  <field name> is the name of the variable field or sub-field
break <break condition> [<ignoreCount> <volatile>]
  break condition is a function name or '*'break address or filename':'linenumber  ignoreCount is
a number
  volatile is a boolean: 'true' or 'false'
delete <breakPoint number>
db <any debugger command>
  the command is directly sent to the debugger with no verification
```

- `db`
  The shell offers a way to directly type debugger commands. You just have to type `"db "` before the actual command and it will be directly passed to the debugger without any verification except for one command that is `"set annotate"` in the Gnu and Tornado integration. This is because with these debuggers, the *SDL-RT debugger* is running with annotate level 2 and would not be able to synchronize anymore with *gdb* if you change it. The consequence for you is that the format of the answer is different from what you are used to but you will get the information. Check *gdb* reference manual for more information.

5.5.6.3 interaction commands

To list all the available commands in this category, type:

`help interaction`

It will list the following commands:

```
Command       - Explanation
---------------------------
set time <new time value>
  new time value can be absolute time or '+'delta
send2name <sender name> <receiver name> <signal number or name> [<parameters>]
send2pid <sender pid> <receiver pid> <signal number or name> [<parameters>]
sendVia <sender pid> <channel or gate name> <signal number or name> [<parameters>]
send <sender pid> <signal number or name> [<parameters>]
  environment name is 'RTDS_Env' and environment pid is '-1'
```

```
  parameters are |{field1|=value|,field2|=value|,...|}
systemQueueSetNextReceiverName <receiver name>
systemQueueSetNextReceiverId <receiver id>
extractCoverage <file name>
connect <port number>
  to connect to an external tool on a socket using the shell format
connectxml <port number>
  to connect to an external tool on a socket using the xml-rpc format
disconnect
  to disconnect from the external tool
startPrototypingGui
```

- `set time`
  This command sets a new system time value if the debugger allows it. Please check the reference manual for more information.
- `connect`
  This command opens a socket in server mode to connect an external tool to the *SDL-RT debugger shell*. The parameter is the port number on the host IP address. This command should be done before starting the client.
- `disconnect`
  Disconnect the socket from the external tool.
- System queue manipulation
  It is possible to re-organize the system queue order from the shell. The `systemQueueSetNextReceiverName` will put up front in the system the next message for the defined receiver name, and `systemQueueSetNextReceiverId` will put up front in the system queue the next message for the defined receiver pid.
- `extractCoverage`
  Extracts the code coverage for the current debug session so far and stores it in the specified file. If the file name is relative, it will be taken from the project directory. Please note that if this command is used in a debug session run via the `rtdsSimulate` command line utility, the project will be saved in the end and the code coverage results stored in it.

5.5.6.4 variables commands

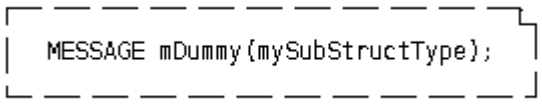
To list all the available commands in this category, type:
`help variables`

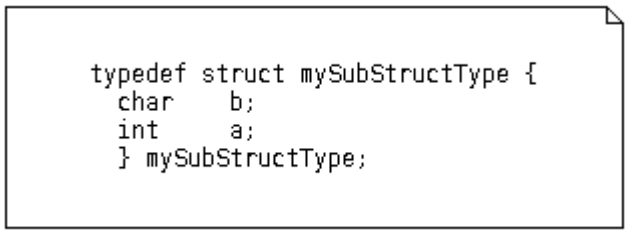
It will list the following commands:

```
Command       - Explanation
---------------------------
varFromType <variable name> <variable type>
  creates a variable of the given type to be used in the shell
varFromValue <variable name> = <initial value>
  creates a variable with the given initial value to be used in the shell
varFieldSet <variable name>[.<field name<]* = <field value>
  sets a single variable field to a given value
```

```
dataTypes <on | off>
  prints the type of the variable
print <variable name>
  prints the variable value
sdlVarSet [<process id>:]<variable name>=<value>
sdlVarGet [<process id>:]<variable name>=<value>
```

- shell variables
  It is possible to define variables in the shell and to use them in send2xxx commands using the `|$(<variable name>)` syntax..
  - `varFromType`
    This command allows to declare a variable based on a type defined in the SDL-RT system. Only the types used as parameters in messages are available. The message parameters need to be defined in a super-structure in order to be compliant with the generated code (except if there is a unique pointer type parameter).
    Example:





    Shell commands to define a variable based on the type:

```
>varFromType myVar mySubStructType
>print myVar
|{b|= |,a|=0|}
>varFieldSet myVar.b=z
>varFieldSet myVar.a=666
>print myVar
|{b|=z|,a|=666|}
>send2name pPing normal mDummy |{|$(myVar)|}
send2name pPing NORMAL_SIGNAL mDummy
|{|{b|=z|,a|=666|}|}
>
```

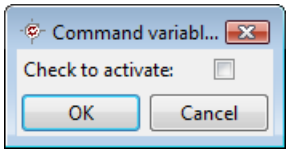
  - `varFromValue`
    This command allows to declare an untyped variable based on its value. Shell commands to define a variable based on its values:

```
>varFromValue myVar=|{b|= |,a|=0|}
```

```
>print myVar
|{b|= |,a|=0|}
>varFieldSet myVar.b=z
>varFieldSet myVar.a=666
>send2name pPing normal mDummy |{|$(myVar)|}
send2name pPing NORMAL_SIGNAL mDummy  |{|{b|=z|,a|=666|}|}
>
```

- `varFieldSet`
  This command sets a field of the variable. This can only be used on simple type fields.
- `print`
  This command prints a shell variable value.

- `dataTypes`
  This command is a verbose mode that displays the type when printing data.
- Accessing variables
  - Shell variables
    RTDS debugger shell variables can be accessed with the `|$[<variable name>]` syntax.
    Example:
    ```
    varFromType myVar mySubStructType
    print myVar
    |{b|= |,a|=0|}
    echo |${myVar}
    ```
    echos:
    ```
    |{b|= |,a|=0|}
    ```
  - Interactive variables
    It is possible to ask the user for a value with the `|${<input label>}` syntax. Options for the input label are: For strings, the only option is its length (default: 20). For booleans, options are the value when checked and the value when
    unchecked, separated by a comma. For example, a field with type "b[-r,]" will be
    replaced in the command by "-r" if the user checks the corresponding check-box, and
    by the empty string otherwise. The defaults are "1" for checked and "0" for unchecked.
    Example:
    ```
    echo |${Check to activate: /b}
    ```
    pops up the following window:

    echos `1` if checked or `0` if unchecked.

5.5.6.5 trace commands

To list all the available commands in this category, type:

```
help trace
```

It will list the following commands:

```
Command       - Explanation
---------------------------
backTrace     - display last events traced when activated in profile
setupMscTrace <time information> <message parameters> [<agents>]
  sets up the MSC trace where:
  <time information> is 0 or 1
  <message parameters> is 0 or 1
  <agents> is the list of agent names to trace separated by spaces
startMscTrace
stopMscTrace
saveMscTrace <file name>
setEnvInterfaceFilter <filter status>
  <filter status> is 1 or 0, when active only messages with the environment will be traced
```

- MSC trace
  The MSC trace can be configured, started, stopped, and saved from the shell.
  Example:
  `setupMscTrace 0 1 pPing`
  Will only trace pPing instance with no time information but with parameters.
- Filtering the interface between the environment and the system
  The `setEnvInterfaceFilter` command is not available in SDL-RT.

5.5.6.6 customization commands

To list all the available commands in this category, type:

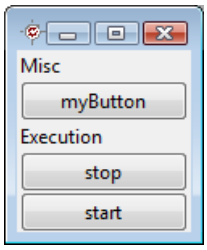
```
help customization
```

It will list the following commands:

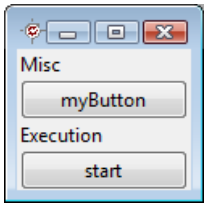
```
Command       - Explanation
---------------------------
buttonWindowCreate <button window name>
  creates a window to contain user defined buttons
buttonWindowAdd <button window name> <button name> = <shell command> [|; <shell command>]*
  adds a button to previously created button window
  <button window name> is the name of the button window
  <button name> is the text to be displayed on the button
  <shell command> is the command associated with the button
buttonWindowDel <button window name> <button name>
  removes a button from a button window
  <button window name> is the name of the button window
  <button name> is the text of the button to be removed
buttonWindowLabelAdd <button window name> <label name>
  adds a label to previously created button window
  <button window name> is the name of the button window
```

```
  <label name> is the text to be displayed on the label
buttonWindowLabelDel <button window name> <label name>
  removes a label from a button window
  <button window name> is the name of the button window
  <label name> is the text of the label to be removed
```

- Button windows
  It is possible to create user-defined buttons and to associate shell commands.
  Here is an example of a button window:
  ```
  >buttonWindowCreate myWindow
  >buttonWindowLabelAdd myWindow Misc
  >buttonWindowAdd myWindow myButton = help
  >buttonWindowLabelAdd myWindow Execution
  >buttonWindowAdd myWindow stop = send2name pPing normal
  mStop
  >buttonWindowAdd myWindow start = send2name pPing normal
  mStart |{param1|=12345|}
  ```



So clicking on myButton will actually execute the help command in the shell.
It is also possible to remove labels or buttons:
```
>buttonWindowDel myWindow stop
```



It is possible to create several button windows.
To stop one of the windows, just close the window.

5.5.7 Status bar

The status bar is divided in two parts:

- The *SDL-RT debugger* internal state
  The *SDL-RT debugger* can have the following internal states:

State	Meaning
STOPPED	The system is stopped

Table 2: SDL-RT debugger internal states

State	Meaning
STOPPING	The system is trying to stop. No commands are allowed in that intermediate state.
RUNNING	The system is running. The traces might be active or not (Options / Free run). A stop is possible in that state.
STEPPING	C code classical stepping. Note a classical step might take a lot of time. A stop is possible in that state.
KEY_SDL_STEPPING	Step to the next SDL key event. Note an SDL step might take a lot of time. A stop is possible in that state.
ERROR	An error has occurred and the SDL-RT debugger is stuck. Restart the SDL-RT debugger.

Table 2: SDL-RT debugger internal states

- The active thread
  The active thread is displayed in the right part of the status bar when known.

5.5.8 Breakpoints

5.5.8.1 Setting breakpoints

There are three ways to set breakpoints:

- In the SDL-RT debugger shell
  `break <break condition> [<ignoreCount> <volatile>]`
  - `break condition` can be
    - a function name
    - break address starting with `'*'`
    - a specific line in a file with the following form: `filename:linenumber`
  - `ignoreCount` is a number meaning how many times the breakpoint should be ignored. For example: to stop when the `break condition` is hit the 5th time `ignoreCount` should be set to 4. The default value is 0.
  - `volatile` is a boolean that can take value 'true' or 'false'. When true the breakpoint is deleted when hit.
- In the text editor
  Select a line in the editor and go to:
  - *Debug / Set breakpoint* menu to set a simple breakpoint,
  - *Debug / Set breakpoint with option* menu to set a breakpoint with ignoreCount,
  - *Debug / Set run until* menu to set a temporary breakpoint.
- In the SDL-RT editor select an SDL-RT symbol and go to:
  - *Debug / Set breakpoint...* menu to open the *Set breakpoint* window to set:
    - on which line the breakpoint should be set in the symbol,
    - if the breakpoint is volatile or not,

- if there should ignoreCount on the breakpoint.

5.5.8.2 Listing breakpoints

The breakpoints set can be listed in the *SDL-RT debugger shell* with the `list` command. It is important to note this listing will only show breakpoints that have been set with *Real Time Developer Studio* tools. For example if a breakpoint has been directly set with gdb it will not appear.

5.5.8.3 Deleting breakpoints

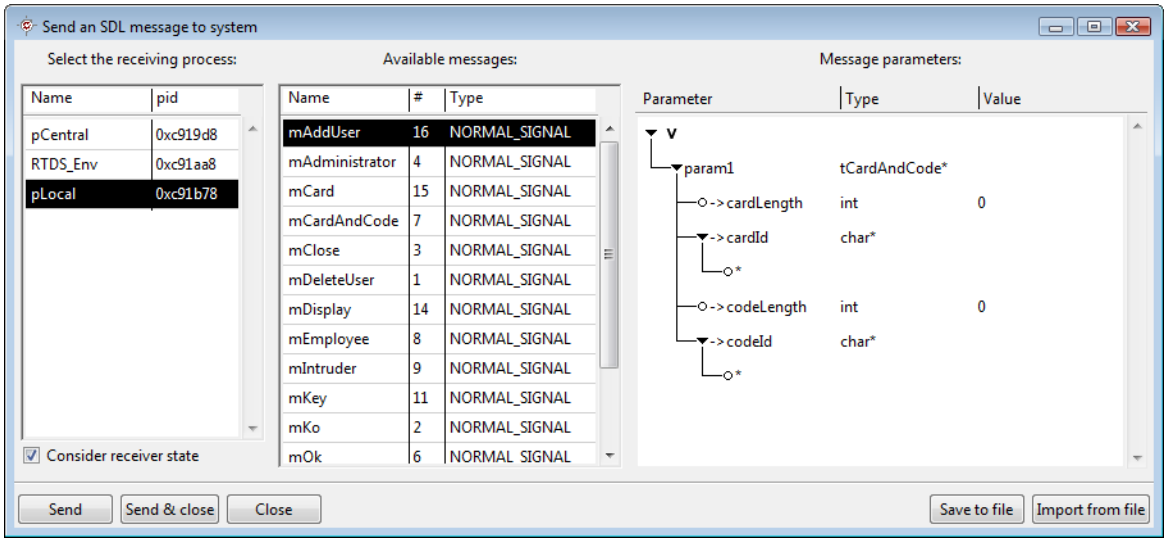
Breakpoints can be deleted from:

- the shell with the delete command:
  `delete <breakpoint number>`
  where the `breakpoint number` is the number listed from the `list` command.
- the text editor as to set one,
- the SDL editor as to set one.

5.5.9 Sending SDL messages to the running system

5.5.9.1 Send SDL message window

The *SDL-RT debugger Send SDL message* button opens the *SDL message send* window. It will list the possible receivers, the available messages and their corresponding parameters in the system:



The SDL message send Window

Please note that it is not possible to set a real pointer value with this interface. All pointers are considered null or to be allocated dynamically on the target. The authorized pointer values are:

- o for null pointers,
- ' ' for pointers to be allocated on the target.

To specify real pointer values please us the shell command described below.

5.5.9.2 Send SDL message shell commands

The equivalent commands in the shell are:

```
send2name <sender name> <receiver name> <signal number or name> [<parameters>]
send2pid <sender pid> <receiver pid> <signal number or name> [<parameters>]
```

Verifications are made on the sender pid and receiver pid only.

The format for the <parameters> argument depends on whether the message is structured or not. Structured parameters are fully described in RTDS Reference Manual. In short, a message is structured if and only if it is declared with several parameters or with one parameter that is a pointer to a struct or a union.

- For a non-structured message, the text for the parameter must be a sequence of bytes written in hexadecimal format, exactly as they will appear in the target program memory.
- For a structured message, the text for the parameter must be written as follows:
  - The values for base types are written as in C: for example `12` or `871` are valid values for an `int`, `X` is a valid value for a `char`, and so on...
  - The values for pointers are written in hexadecimal, optionally prefixed by `0x`, and followed by `|:` and the pointed value. If the value for the pointer is not specified, a new block will be automatically allocated on the target. For example, for an `int*`:
    - `804A51FE|:67` will set the pointer to the hexadecimal value `0x804A51FE` and put `67` in the pointed value;
    - `|:123` will allocate a new `int*` on the target and put the value `123` in it;
    - `0x0` will set the pointer to `NULL`.

    There is a special case for `char*` pointers: the value can be a full string instead of just a single `char`. Please note all '|' characters must be doubled in this string.
  - The values for structs or unions are coded as follows:
    `|{field1|=value|,field2|=value|,...|}`
    For example, for a struct defined as:
    `struct MyStruct { int i; char *s; };`
    a valid format is:
    `|{i|=4|,s|=|:abcd|}`
    In the struct created on the target, the field `i` will be set to `4` and the field `s` will be automatically allocated with length 5 and the string will be set to `"abcd"`.
    Please note that what is significant in the formatted text is not the field names, but the field order; so in the example above, you can't write:
    `|{s|=|:abcd|,i|=4|}/* INVALID! */`
    As a consequence, the field names are in fact optional, so you can write:
    `|{|=4|,|=|:abcd|}`
    Please also note that if no value is specified for a field, the field is left as is. This can be used to set the value for fields in a union. For example, for:
    `union MyUnion { int i; void *p; };`
    a valid format is:
    `|{i|=|,p|=0x0|}`
    The field `i` won't be set and the field `p` will be set to `NULL`.
  - Escape sequences

Use a || to introduce a | in the message parameters,
Use a |. to introduce a carriage return in the message parameters.

Please note the transport structures automatically generated by RTDS must be taken into account. So for a message declared via "`MESSAGE msg(int, char*);`", an example text for the parameters is:

```
|{param1|=12|,param2|=|:my string|}
```

Please refer to the Reference Manual for details on transport structures for messages.

5.5.9.3 Prototyping GUI

This is the easiest way to interact with the system. The interface editor is described in “Prototyping GUI” on page 108. The interface is started with the following quick button:

5.5.9.4 Button windows

Interaction commands can easily be assigned to graphical buttons as described in “interaction commands” on page 202.

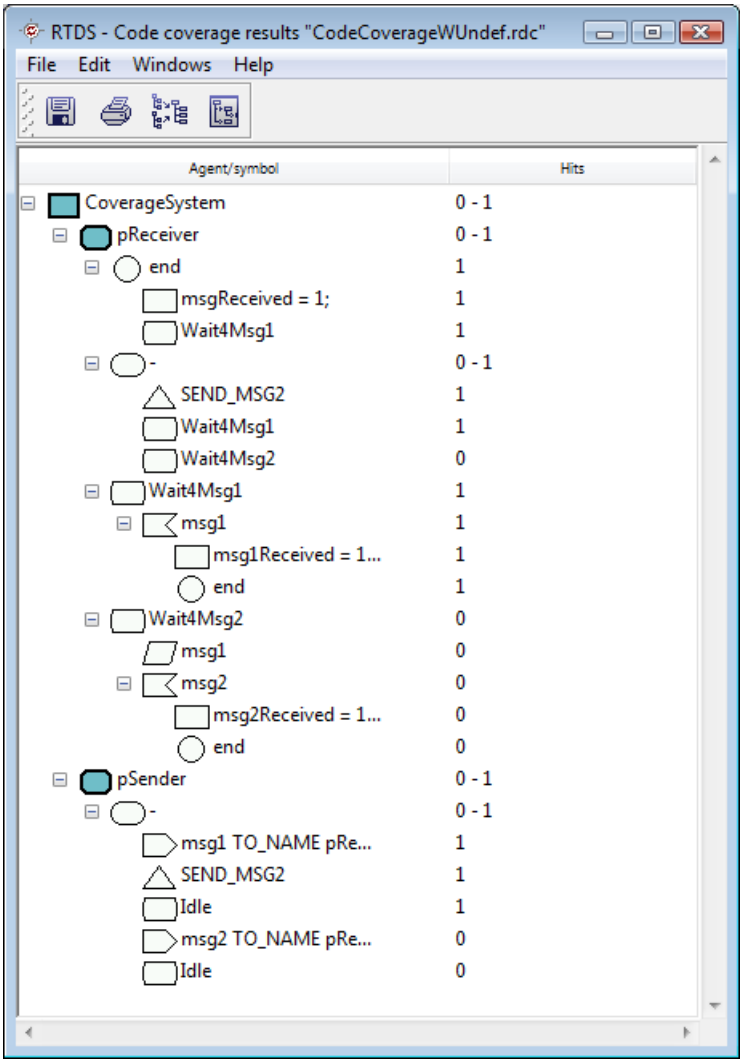
5.5.10 Testing

If no process called RTDS_Env is defined in the SDL-RT system, one is generated automatically by the code generator to represent the environment. When handling complex messages with the environment it is not handy to define the messages manually. The easiest way is to define a test process or block called RTDS_Env that will be the testing scenario. Sending messages from the SDL-RT debugger is a good way to trigger specific test scenarios.

5.5.11 Code coverage

The debugger’s *Get code coverage* button gets the code coverage analysis results for the running system so far. This feature is available only if the *Gen. code coverage info.* is checked in the generation options (see “Profiles” on page 133).

Clicking on the button will generate a new code coverage analysis document, include it in the project tree and open it in the following window:



Code coverage analysis result window

The tree shows:

- At its first level, all processes in the system;
- At its second level all states, connector entries and start symbols in each process;
- At its third level, all message inputs, message save and continuous signals for each state;
- At its last level, all symbols in the transition.

For each node is displayed the minimum and maximum number of hits for the symbol or transition or process. If the minimum and maximum are the same, a single number is displayed.

The tree may be expanded, collapsed and sorted using the "Edit" menu. Double-clicking on a node will display the corresponding symbol if any.

NB: the states displayed at the second level of the tree are just a way to summarize the information for all transitions for this state. Therefore:

- The numbers displayed for the node are not the number of times the process went into that state. It's the number of transitions with this state as initial state executed by the process.
- There is no symbol corresponding to such a node: for a given state, each transition may be represented with a specific state symbol in the diagram, but only one state symbol will appear in the code coverage results. So it can't be associated to a single symbol.

5.5.12 Connecting an external tool

It is possible to connect an external tool to the *SDL-RT debugger* through a socket. To allow connections to the *SDL-RT debugger* the `connect` command should be entered in the *SDL-RT debugger shell*:

```
connect <port number>
```

The IP address used is the IP address of the host where the *SDL-RT debugger* is running. Only the port number can be configured.

The *SDL-RT debugger* is seen as a server so the connect command should be executed before starting the client.

Once the connection is made the client has basically a direct access to the shell commands: whatever is sent goes to the *SDL-RT debugger shell* and whatever the shell replies goes to the socket. Therefore the syntax is the one used in the shell. Note the external tool connected will also receive any information that is printed out in the shell.

To close the socket use the `disconnect` command in the *SDL-RT debugger shell*.

Here is a sample code in Python (http://www.python.org) that connects to port 50010:

First start the server in the *SDL-RT debugger shell*:

```
connect 50010
```

Then go to a shell or DOS window and type:

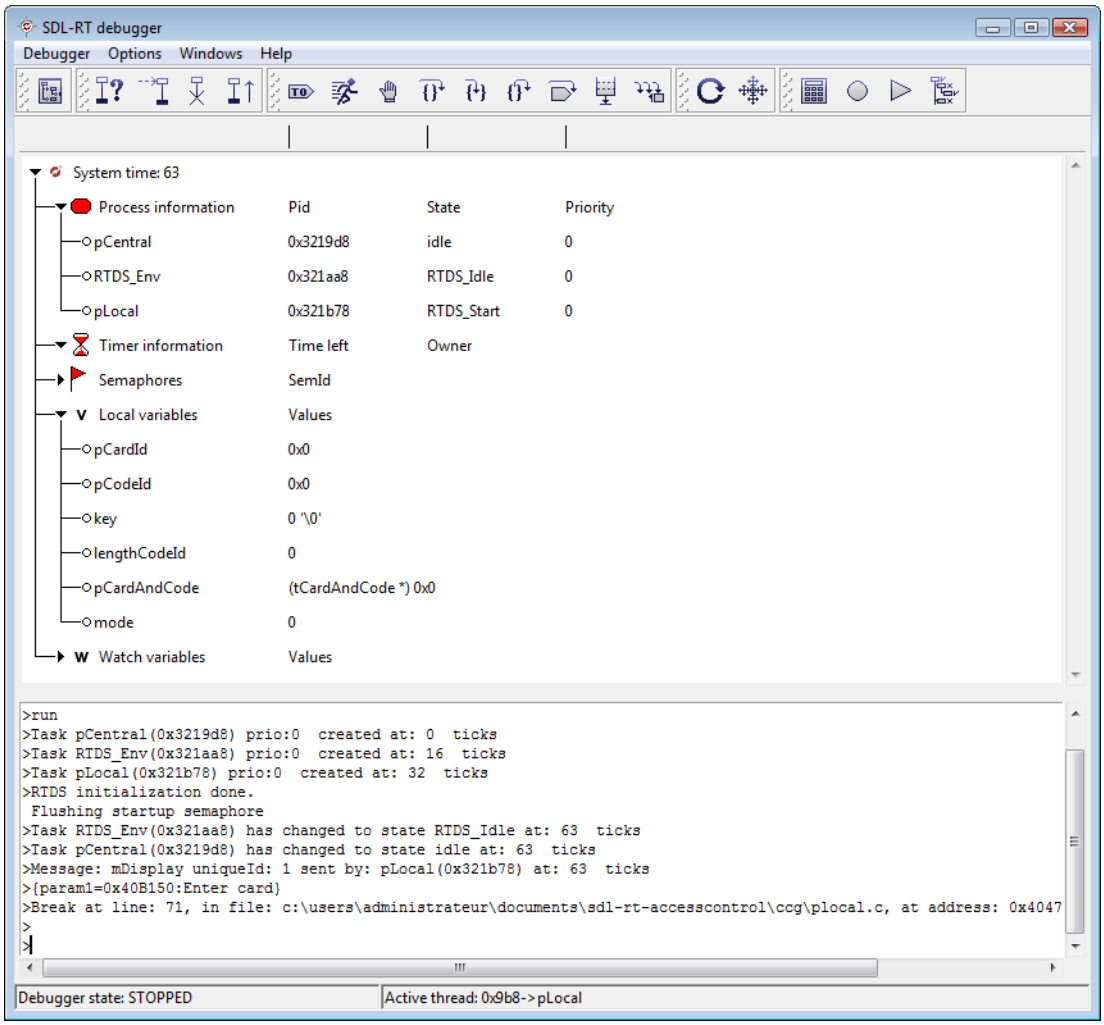
```
python
>> from socket import *
>> s=socket(AF_INET, SOCK_STREAM)
>> s.connect((gethostname(), 50010))
>> s.send('help\n')
>> print s.recv(500)
```

It will print out the 500 first characters of the *SDL-RT debugger* help and display it in the *SDL-RT debugger shell*.

5.5.13 Debugger tree view

An alternate view of the SDL-RT system information is available displayed as a Tree. It is possible to switch from one to the other during a debug session through the *Windows/*

Change to tree debugger window menu. This view is interesting because it is more compact than the classical one.


SDL-RT debugger
Debugger Options Windows Help
System time: 63
Process information Pid State Priority
pCentral 0x3219d8 idle 0
RTDS_Env 0x321aa8 RTDS_Idle 0
pLocal 0x321b78 RTDS_Start 0
Timer information Time left Owner
Semaphores SemId
Local variables Values
pCardId 0x0
pCodeId 0x0
key 0 '\0'
lengthCodeId 0
pCardAndCode (tCardAndCode *) 0x0
mode 0
Watch variables Values
>run
>Task pCentral(0x3219d8) prio:0 created at: 0 ticks
>Task RTDS_Env(0x321aa8) prio:0 created at: 16 ticks
>Task pLocal(0x321b78) prio:0 created at: 32 ticks
>RTDS initialization done.
Flushing startup semaphore
>Task RTDS_Env(0x321aa8) has changed to state RTDS_Idle at: 63 ticks
>Task pCentral(0x3219d8) has changed to state idle at: 63 ticks
>Message: mDisplay uniqueId: 1 sent by: pLocal(0x321b78) at: 63 ticks
>{param1=0x40B150:Enter card}
>Break at line: 71, in file: c:\users\administrateur\documents\sdl-rt-accesscontrol\ccg\plocal.c, at address: 0x4047
>
Debugger state: STOPPED
Active thread: 0x9b8->pLocal

It is the possible to expand or collapse part of the information as well as drag and drop to re-order the tree. The *Windows/Change to classical debugger window* returns to the classic display of the SDL-RT debugger.

5.5.14 Command line debug

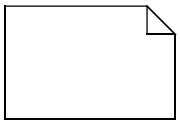
The SDL-RT debugger can be started from a shell or a DOS console and run an execution script automatically with the `rtdsSimulate` command. Check the Reference manual for more information.

6 - SDL Z.100 project

6.1 - SDL types and data declarations

The types and data declarations in SDL projects are defined in the ITU-T recommendation Z.100. The supported version is SDL-92 some restrictions or additions described in the following paragraphs.

All declarations are made in standard text boxes:



The dashed text-box used for SDL-RT declarations in SDL-RT projects is not used.

6.1.1 General restrictions

The following SDL-92 features are not supported in RTDS:

- Declarations referencing each other will not work. For example:

```
/* Uses synonym toto_dflt as default value */
NEWTYPE toto
STRUCT
  i INTEGER;
  s CHARSTRING;
DEFAULT toto_dflt;
ENDNEWTYPE;

/* Uses type toto for synonym type */
SYNONYM toto_dflt toto = (. 0, 'xxx' .);
```

  will *not* work.
- Qualifiers in identifiers (`<<qualifier>> name`) are not supported.
- Optional definitions via `SELECT` are not supported.
- Context parameters are not supported.

6.1.2 Pre-defined sorts

The following pre-defined sorts are available:

- Boolean
- Integer
- Natural
- Real
- Character
- CharString
- Time
- Duration
- Pid

Literal names for control characters such as NUL, STX or DEL are not supported. These characters must be created via the Num standard operator with the corresponding ASCII code.

All standard operators are available, with the following additions and restrictions:

- The operations available on the CharString sort are also available on the Character sort. So the expression:
  s := 'foo' // 'o'
  is valid (in strict SDL-92, this should be written: s := 'foo' // MkString('o')). The standard MkString operator is however still supported.
- The internal operators (operators with name ending with '!') are not supported.

Here is a complete list of supported operators for all pre-defined sorts:

- Num : character -> integer
- Chr : integer -> character
- MkString : character -> charstring
- Length : charstring -> integer
- First : charstring -> character
- Last : charstring -> character
- Substring : charstring, integer, integer -> charstring

6.1.3 NEWTYPE declarations

The standard SDL-92 NEWTYPE declaration is supported, with the following additions and restrictions:

- By default, the scope for NEWTYPE's is global: having two types with the same name in two different agents will not work. To get regular SDL behavior, the option "Manage all types in a single system-wide scope" in the project generation options must be unchecked.
- Inheritance is not supported.
- Choice sorts are supported. These can be written either in SDL-2000 syntax:
  ```
  NEWTYPE MyChoiceType
  CHOICE
    field1 Type1;
    field2 Type2;
  ENDNEWTYPE;
  ```
  or in ObjectGeode syntax:
  ```
  NEWTYPE MyChoiceType
  CHOICE {
    field1Type1,
    field2Type2
  }
  ENDNEWTYPE;
  ```
  ObjectGeode syntax will however issue a warning when used since it is non-standard.
- In STRUCT or CHOICE types defined via the SDL-92 syntax, the ';' after the list of fields is mandatory.
- Optional fields in STRUCT types are supported: for each optional field x in a STRUCT, a read-only boolean pseudo-field xPresent is added, indicating

wether x is present or not. A field is set present when a value is assigned to it. There is no way of setting back a present field 'non present'. The notation for STRUCT initializers with missing fields '(. x, , z .)' is not supported.

- The available pre-defined generators are:
  - Array with the standard notation for array initialisation '(. x .)' and element access for reading and writing my_array(index);
  - PowerSet with the standard operators incl, del, take and length;
  - String with the standard operators mkstring, length and //. Operators first, last and substring are only available for the CharString sort.
- User-defined generators are not supported.
- LITERALS in a NEWTYPE can only be used alone. Mixing literals with STRUCT or CHOICE or a generator will issue a syntax error.
- The CONSTANTS clause in a NEWTYPE is not supported.
- Ordered literal types (via OPERATORS ORDERING) are not supported.
- Operator diagrams are not supported, as well as textual operator declarations.
- Operators defined without parameters are supported, but will generate a warning. Calls to these operators may be written operator() or just operator.
- Polymorphism for operators is not supported, i.e. two operators cannot have the same name, even if their parameter types are different.
- Quoted infix operator names are not supported ("+", "*", etc...)
- Operators declared EXTERNAL are not supported.
- Extended literal or operator names are not supported.
- AXIOMS are not supported.
- Indices for ARRAY type can only be of basic types. Indices of complex types such as STRUCT or CHOICE are not supported.

6.1.4 SYNTYPE declarations

The standard SDL-92 SYNTYPE declaration is supported, with the following additions and restrictions:

- The scope for SYNTYPE's is managed as the one for NEWTYPE's: global by default, hierarchical on option (see "NEWTYPE declarations" on page 216).
- The closed ranges in CONSTANTS clauses may be written either *min*:*max* (standard), or *min*..*max*.
- ObjectGeode syntax for SIZE constraints is supported, so it's possible to write:
  ```
  SYNTYPE MyStringType = CharString(SIZE(0:16)) ENDSYNTYPE;
  ```
  instead of:
  ```
  SYNTYPE MyStringType = CharString SIZE(0:16) ENDSYNTYPE;
  ```
  The first syntax will however issue a warning since it is non-standard.

6.1.5 SYNONYM declarations

The standard SDL-92 SYNONYM declaration is supported, with the following restrictions:

- The scope for SYNONYM's is managed as the one for NEWTYPE's: global by default, hierarchical on option (see "NEWTYPE declarations" on page 216).
- A synonym for a structure or array primary (. ... .) will not work if the type is not specified. So the following SYNONYM declaration:
  ```
  SYNONYM myValue = (. 'xxx', 0 .);
  ```

is *invalid* and must be re-written:

```
SYNONYM myValue MyStructType = (. 'xxx', 0 .);
```

- External synonyms are not supported.

6.1.6 FPAR & RETURNS declarations

The standard SDL-92 `FPAR` declaration is supported with no restriction in process, process type and procedure diagrams, as well as the `RETURNS` declaration in procedures; `RETURNS` declarations with a variable name are not supported.

These two declarations must however be placed alone in a text box, preferably together if both are present.

6.1.7 TIMER declarations

The standard SDL-92 `TIMER` declaration is supported with the following restriction: timer parameters are not supported. The unit for the timer duration is seconds.

Please note that the declaration for a timer is not mandatory: if a `SET` with a time-out value is present in a process or procedure, the timer is automatically declared. The declaration must however be done if the timer is started using a `SET` without time-out value.

6.1.8 SIGNAL & SIGNALLIST declarations

The standard SDL-92 `SIGNAL` and `SIGNALLIST` declarations are supported with the following restrictions:

- Signal and signal list names are case-sensitive.
- Signal inheritance is not supported.
- Refining signals to sub-signals is not supported.

6.1.9 SIGNALSET declarations

`SIGNALSET` declarations are not needed and not supported in RTDS.

6.1.10 USE declarations

The `USE` declarations have today the semantics it has in SDL-RT projects, which means:

- `USE` clauses may appear at all levels in the architecture.
- Only one `USE` clause is accepted per diagram.
- `USE` clauses are inherited only in child diagrams that do not have their own `USE` clause. If they have one, it will shadow their parent's `USE` clause.
- Specifying imported items in `USE` clauses is not supported (e.g. "`USE MyPackage / NEWTYPE MyType`" is invalid)

`USE` clauses may not be mixed with other declarations in a text box.

Please note these differences with the standard are considered when exporting to a PR file: all USE clauses are inserted at system level, in conformance with the Z100 PR format.

6.1.11 INHERITS declaration

The standard SDL-92 `INHERITS` declaration is supported in process type diagrams. Inheritance is not available for block types. This declaration must be placed alone in a text box.

6.1.12 Data declarations (DCL)

The standard SDL-92 `DCL` declaration is supported with no restrictions. Remote variables are not available, so the `REMOTE`, `IMPORTED`, `EXPORT` and `IMPORT` declarations are not supported.

6.1.13 Structural element declarations

All standard SDL-92 structural element declarations are supported, except system types, procedure types, and service types, and with the addition of the SDL-2000 composite state:

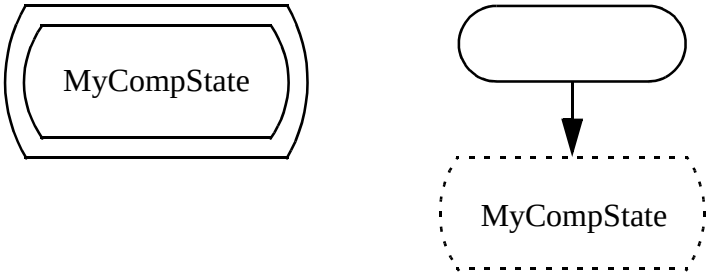
- System
- Block
- Process
- Procedure
- Package
- Block type (named *block class* in RTDS)
- Process type (named *process class* in RTDS)
- Composite state
- Service
- Macro

The following restrictions apply:

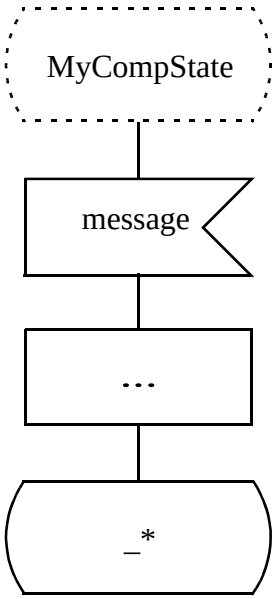
- Names for these elements are case-sensitive.
- Process types are only allowed in packages and cannot be defined in systems, blocks or block types.
- Inheritance in block types is not supported, so `VIRTUAL`, `REDEFINED` or `FINALIZED` processes or process types in block types are not needed and not supported.
- Inheritance for procedures is not supported.
- Remote procedures are not supported.
- Package diagrams are not supported. To define the contents of the package, the following diagrams and files are used:
  - For textual declarations (e.g. types, synonyms, signals, ...), a SDL declaration file (`.rdm`) is used, similar to the one used in SDL-RT projects.
  - For agent classes declarations, a class diagram is used as in SDL-RT projects (see “Class description” on page 117). In SDL projects, these class diagrams only allow to declare process and block classes.
- Gates in process and block classes are declared as in SDL-RT projects, i.e. in their parent package’s class diagram. SDL-style gate definitions inside class diagrams are not supported.
- Macro diagrams can only contain a single pseudo-transition, starting with a macro inlet. State symbols are not supported in macro diagrams, as well as

inputs, priority inputs, continuous signals or saves. Declarations are not supported in macro diagrams, except for the macro formal parameters.

- The graphical representations for SDL-2000 composite states and for SDL-92/96 services have been merged:
  - A composite state never directly contains a state machine. The diagram associated to a composite state always contains one or more "concurrent state machines", similar to SDL-92/96 services and represented the same way. The channels from the parent process boundary services and between servics have also been re-introduced in composite state diagrams.
  - Composite state diagrams cannot define entry points for the state machines it contains (restriction from SDL-2000).
  - Composite states in processes must be declared with the symbol used in SDL-2000 for composite state types, and should be used with the symbol used in SDL-2000 for composite state type instanciation:



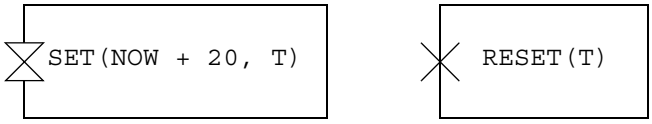
  This allows to graphically distinguish composite states from "normal" states.
  - History states are available with the SDL-2000 syntax:



6.2 - SDL symbols syntax

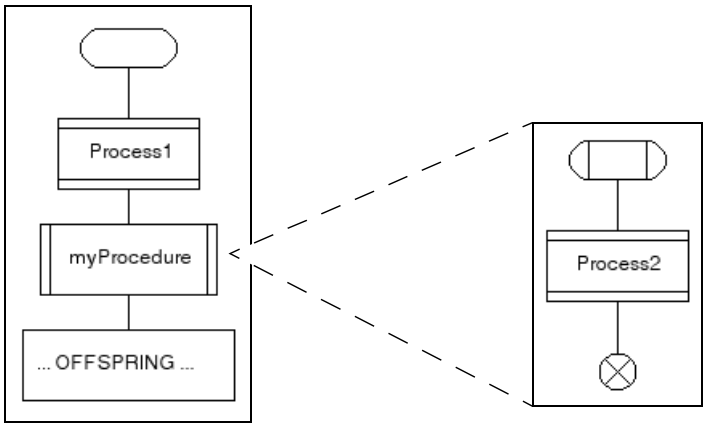
The syntax for all symbols is compliant with the SDL-92 Z100 recommendation, with the following exceptions:

- Virtualities (VIRTUAL, REDEFINED, FINALIZED) in start, input, save and continuous signal symbols are valid, but ignored: all transitions are considered virtual by default.
- For timers, SET and RESET symbols have the shape they have in SDL-RT:



- In signal input and save symbols, NONE or PROCEDURE ... are not supported.
- In signal output symbols:
  - Only one signal can be specified.
  - Specifying the receiver with both TO and VIA is not supported.
  - VIA may only be followed by a single gate or channel name.
- In expressions, the pseudo-operator ANY or ANY(sort) is not supported.

The pre-defined variables SELF, PARENT, OFFSPRING and SENDER are available in processes, process types and procedures. Please note however that procedures defined in processes do not use their parent process's SENDER and OFFSPRING variables, but have their own local ones. So for example, in this case:



the OFFSPRING used in the process's task block will be the pid for Process1, not the one for Process2. Note however that the values for the SENDER and OFFSPRING variables are initialized with the values found in the parent proess when entering a procedure.

The pre-defined variable THIS in process types is not supported.

6.3 - SDL Z.100 Simulation

Two ways of debugging a SDL system are available in RTDS:

- The system can be transformed to C code and debugged with the same debugger as for SDL-RT;
- The system can be executed within RTDS using an internal simulator.

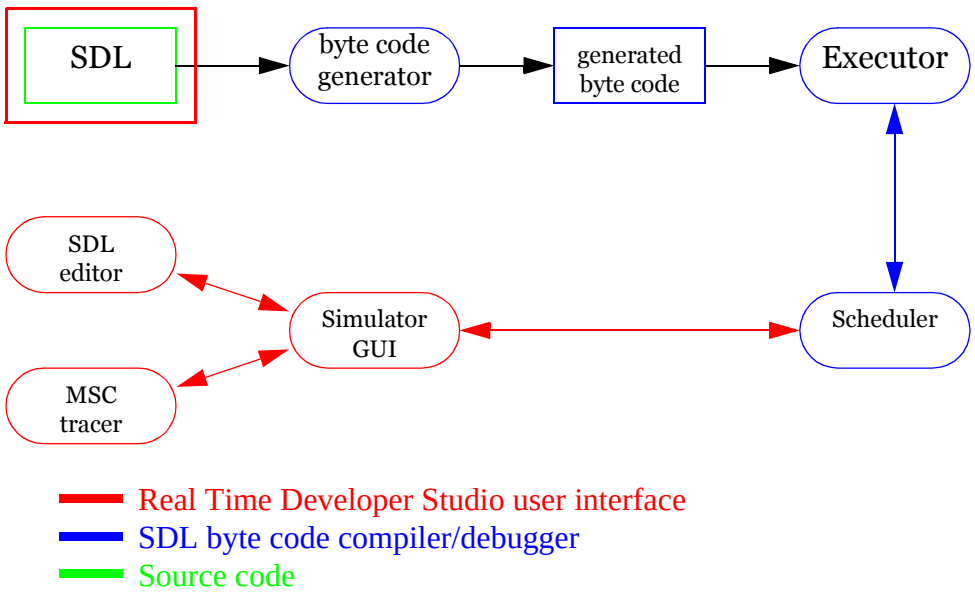
Both approaches have their advantages and drawbacks:

- When exporting the system to C code:
  - The C code is compiled to a native executable, so the execution is quite fast.
  - The supported concepts are limited; the limitations are the same as in SDL to SDL-RT conversion, as described in the corresponding section in the Reference Manual.
  - The execution semantics is not the one described in the Z100 standard, but the one of the underlying RTOS, which can be quite different.
- When using the internal simulator:
  - Since the execution happens within RTDS, a far better control of the running system is available.
  - The code in the SDL system is actually interpreted, so the execution is slower than when exporting to C.

The architecture and options for the C code generation approach are exactly the same for SDL and SDL-RT, so they won't be described again here. For details, please refer to the sections "Code generation" on page 131 and "SDL-RT debugger" on page 187. This section describes the internal RTDS simulator.

6.3.1 Simulator architecture

The *SDL simulator* allows you to execute and debug your SDL system. To do so *Real Time Developer Studio* generates a byte code out of the SDL description and executes it.



The *SDL simulator* has all the expected features of a debugger. It allows you to:

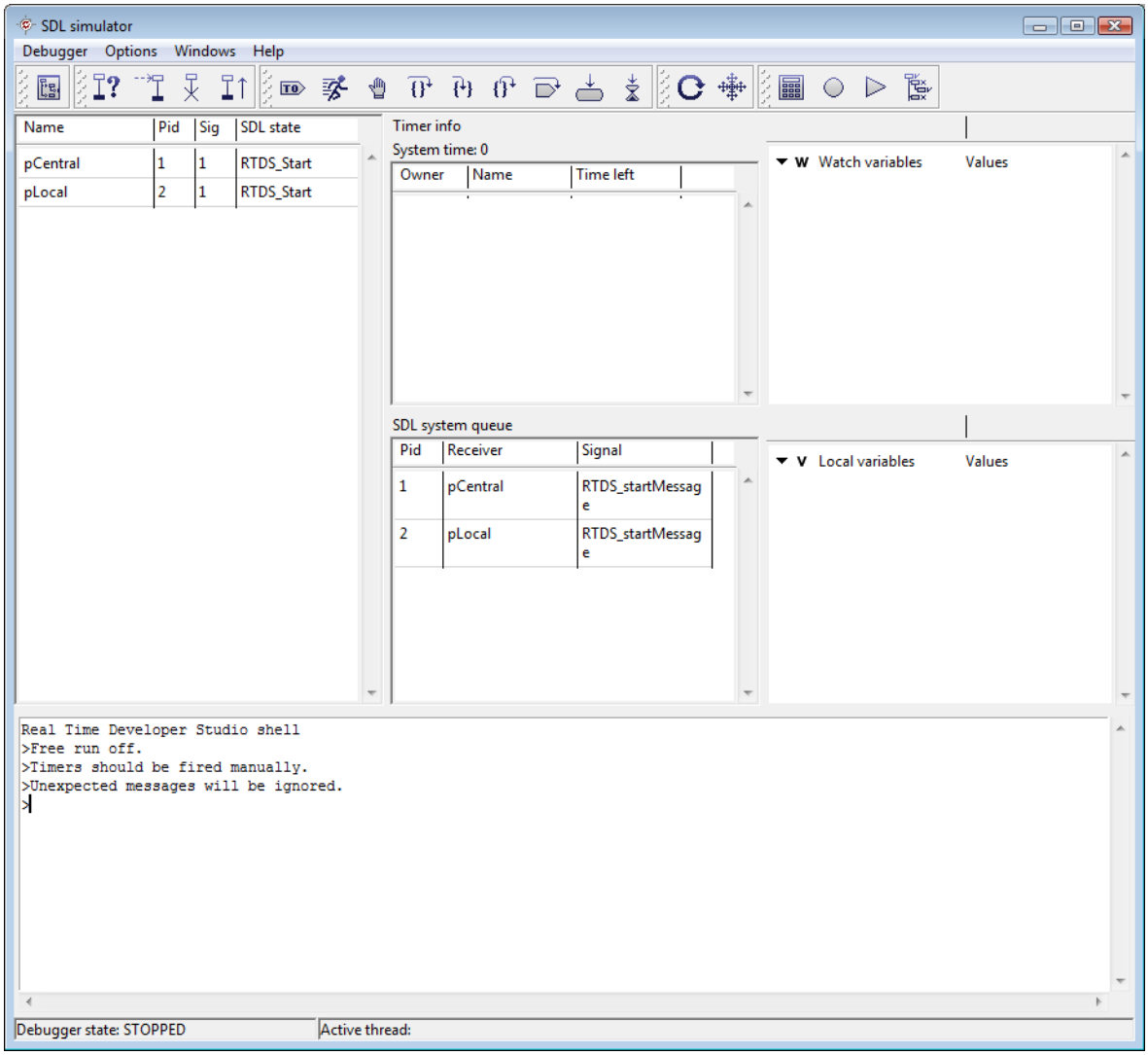
- Graphically trace the internal behavior of the system

- Graphically step in the SDL diagrams
- Visualize all key internals of your system such as:
  - Processes,
  - Timers,
  - Local variables in the current process,
  - Pending messages in the system.
- Send SDL messages to your system,
- Modify SDL state,
- Modify variables value.

6.3.2 Launching the SDL simulator

The *SDL simulator* is started from the *Project manager Generate / Simulate* menu or from the quick button.

Byte code is generated out of the SDL description and the simulation environment is started in the background. The *SDL simulator* window is started automatically and you are ready to debug your system.



The SDL simulator window

All static processes are already present in the Process information list and each static process has its Start message pending in the SDL system queue.

The SDL simulator can be restarted at any time with the reset button or shell command. The underlying simulation environment is restarted and cleaned up.

6.3.3 Stepping levels

Since your source code is a composite of graphical SDL symbols and textual SDL lines of code, the *SDL simulator* offers several ways to execute the code:

- Run with SDL key events trace information,

  Menu *Options / Free run* de-activated. This is the default setup where the SDL simulator traces all SDL key events and displays textual and / or SDL and / or MSC traces.

- Run without SDL key events trace information,

  Menu *Options / Free run* activated. When this option is activated the system runs freely and no trace information is printed.

- Stop execution,

  Stops execution of the running system.

- Stepping

  Step line by line in the SDL code,

  Step-out of an SDL procedure function,

  Step-in a SDL procedure.

- Step until the next SDL key event such as:

  - Message sending,
  - Message received,
  - Timer started,
  - Timer cancelled,
  - Timer went off,
  - SDL state modification,
  - SDL process created,
  - SDL process deleted.

- Run until the end of the transition,

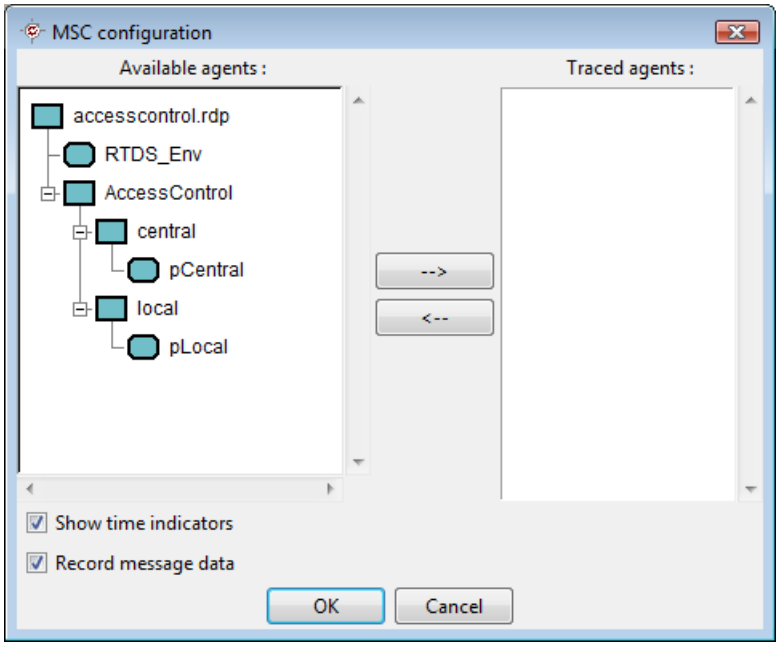
- Run until all signals are consumed except timers.

6.3.4 MSC trace

The MSC tracer allows you to graphically trace execution of the system with its SDL key events. It is possible to configure the MSC trace to define at which level of details the architecture of the system should be represented. The MSC trace can be made at system, block, process or any combination of agents. Any agent selected will be represented by a lifeline in the MSC diagram. Any messages exchanged inside the agent will not be seen on the MSC. The default view is the most detailed one, with a lifeline for each process.

- Configure the MSC trace

The quick button opens the MSC trace configuration window:



The following options are available:
- Show system time information,
- Record and display message parameters,
- SDL architecture elements to trace.

- Start the MSC trace
  - The quick button starts the *MSC Tracer*. By default the trace is active.
- Stop the MSC trace
  - The quick button stops the *MSC Tracer*.
- Trace the last SDL events (backTrace)
  - The quick button opens an *MSC Tracer* and displays the last SDL events. The number of logged events is between 50 to 100.

6.3.5 Displayed information

The *SDL simulator* window is divided in 5 parts described below.

If needed, the displays can be refreshed at any time with the `refresh` button or shell command.

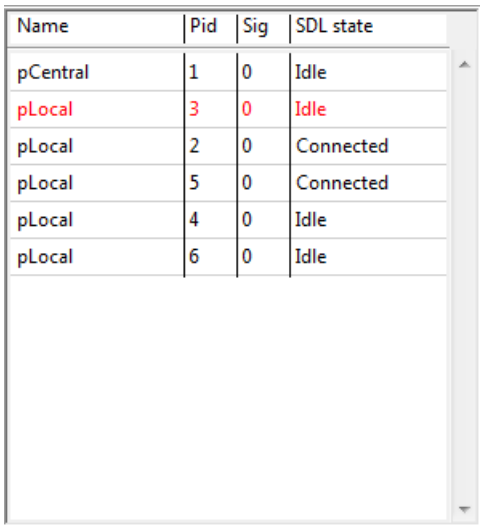
The information to refresh can be setup in the *Options / Refresh options...* menu as explained in “Refresh options” on page 233.

6.3.5.1 Processes

The *Process information* part list all processes defined in the SDL system. The displayed information is:

- Name
  This field displays the name of the process as defined in the Process create SDL symbol. Several tasks can have the same name. The Pid should then be used to distinguish them.
- Pid
  This field shows the unique internal Process Identifier of the process.
- Sig
  This field shows the number of signals waiting in the process queue.
- SDL state
  This field is the internal SDL state of the SDL process as defined in the SDL diagram. The `RTDS_Start` signal is a signal used to execute the start transition of the process.

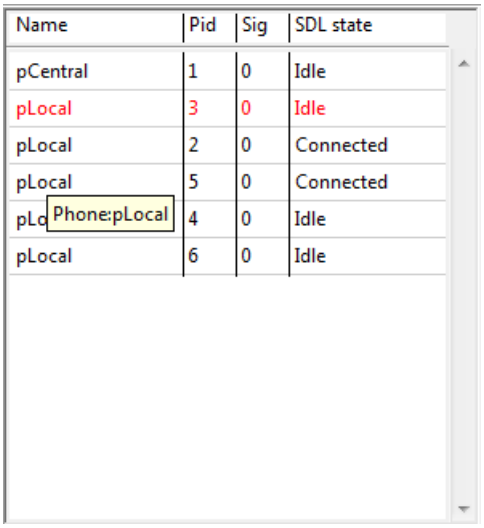
When the system is running the active process line is printed in red.



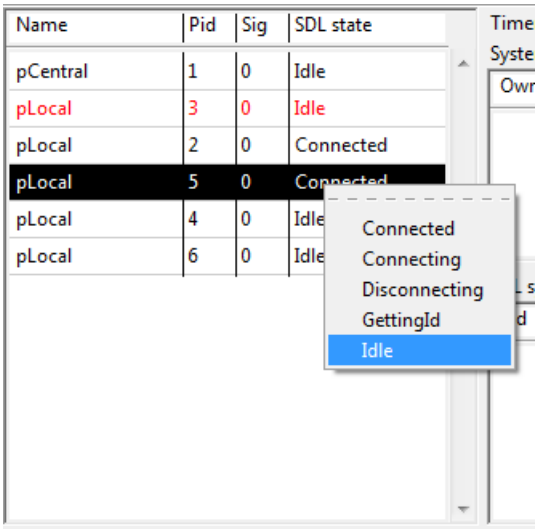
Name	Pid	Sig	SDL state
pCentral	1	0	Idle
pLocal	3	0	Idle
pLocal	2	0	Connected
pLocal	5	0	Connected
pLocal	4	0	Idle
pLocal	6	0	Idle

Process information window

To distinguish processes with the same name but in a different block, a tool tip shows up when the cursor is over the process name and displays the full architecture path down to the process.

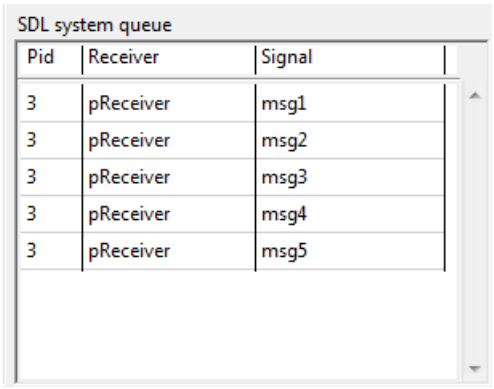


The *SDL simulator Process information* window also allows to modify the SDL state of a process. To do so right click on the SDL state column of the process line. A pop up menu will list all the available SDL state that have been defined in the system. Select one and the SDL state is modified.



6.3.5.2 System queue

RTDS SDL simulator handles all pending signals in a single system queue.



The displayed information is:

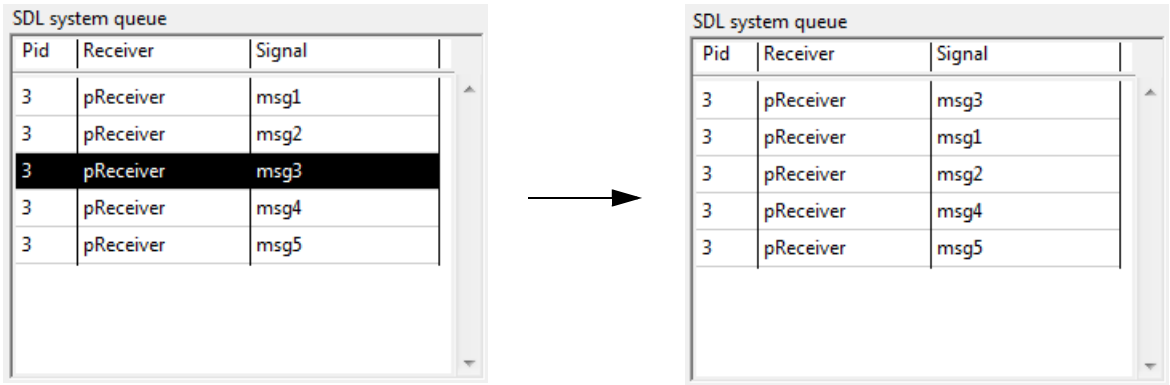
- Pid
  This field shows the unique internal Process Identifier of the receiver process of the pending signal.
- Receiver
  This field displays the name of the receiver process of the pending signal.
- Signal
  This field shows the name of the pending signal.

That allows to :

- Execute the signal inputs in the order the signals have been sent,
- Re-order the pending signals.

That is a key feature of the RTDS SDL simulator since it makes the process scheduling indeterministic allowing full system validation whatever the ordering is.

The signal on the top is the next to be executed. Double click on a signal in order to put it up front in the system queue:



System queue re-organization example

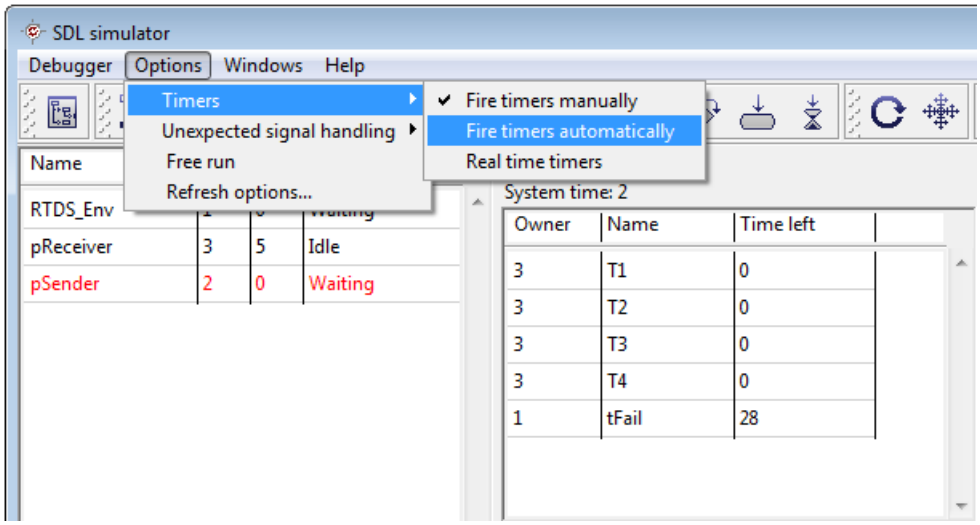
6.3.5.3 Timers

The *Timer info* part displays all on-going timers started from the SDL design. The displayed fields are:

- Pid
  Identifier of the process that started the timer.
- Name
  Name of the timer as defined in the SDL design.
- Time left
  Time left before the timer goes off.

SDL semantic specifies a transition takes no time, so system time does not increase unless a timer goes off or a new system time value is set.

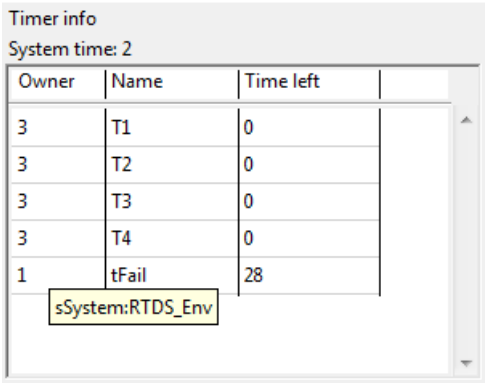
There are 3 ways to manipulate timers in the simulator. Selection is done through the *Options / Timers* menu:



Timer handling selection menu

- **Fire timers manually**
  In that mode, once all signals in the system have been executed, the system hangs. To make a timer go off, double click on the timer line. System time will increase by the value of the timer's time left and all other timers with a value less or equal will also be fired.
- **Fire timers automatically**
  In that mode, once all signals in the system have been executed, the internal scheduler will automatically fire the first timers in the list and increase system by the timer left value.
- **Real time timers**
  In that mode, once all signals in the system have been executed, a timer thread is started that generates a timer tick every second. When the timer tick is received, the system time value is increased by one. When the time left value of the first timer reaches 0, the timer is fired. That implicitly means the delay expressed when starting a timer is set in seconds in that specific mode.

When the cursor is over an owner in the timer list, a tool tip indicates the architecture path down to the timer receiver.



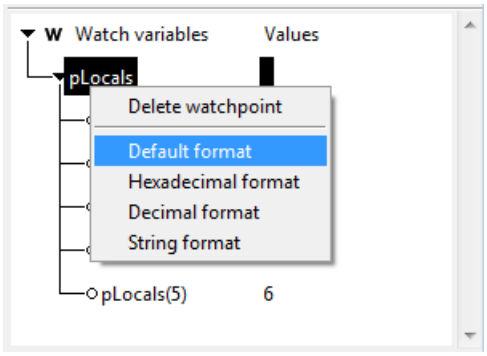
6.3.5.4 Watch

There are several ways to add a variable in the *SDL simulator Watch window*:

- From the shell
  Type the following command in the shell:
  `watch add <variable name>`
- From the SDL editor
  Select an expression in the SDL editor and go to the *Debug / Watch* menu to add the expression in the *SDL simulator Watch Window*.

Variables can be removed from the *SDL simulator Watch window:*

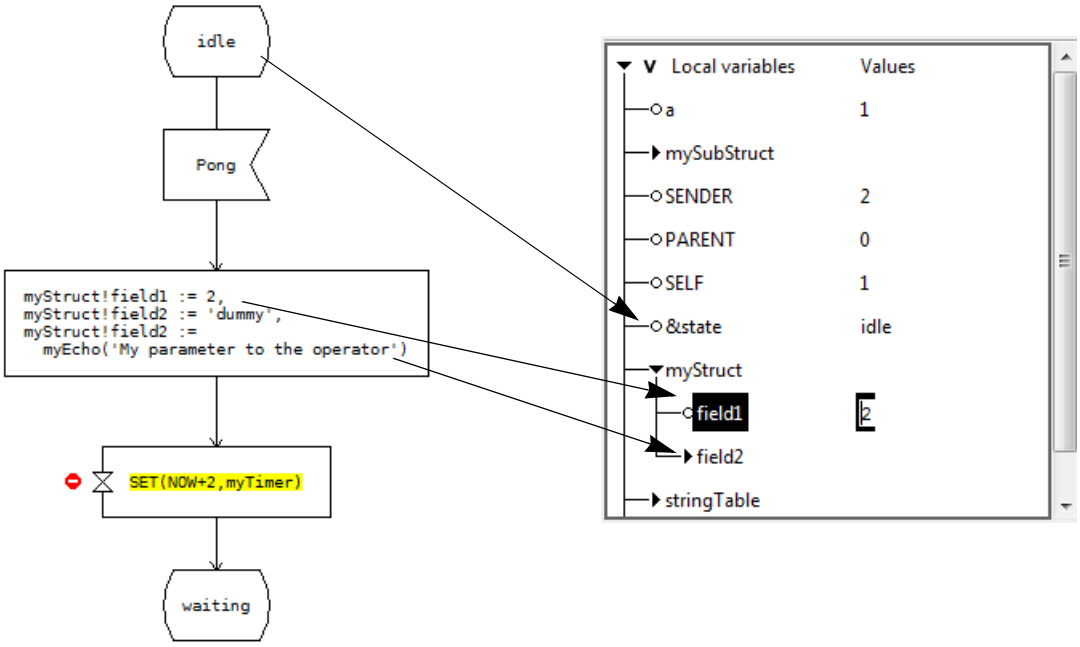
- from the shell with the following command:
  `watch del <variable name>`
- from the *SDL simulator Watch window* with right mouse button *as shown below:*



The *SDL simulator Watch window* also allows to modify the value of variables. To do so select the value of the variable, and double click on it to edit the value. Press `<Return>` and the value is updated !

6.3.5.5 Local variables

When stepping through the code the *SDL simulator* automatically displays the local variables of the current process:

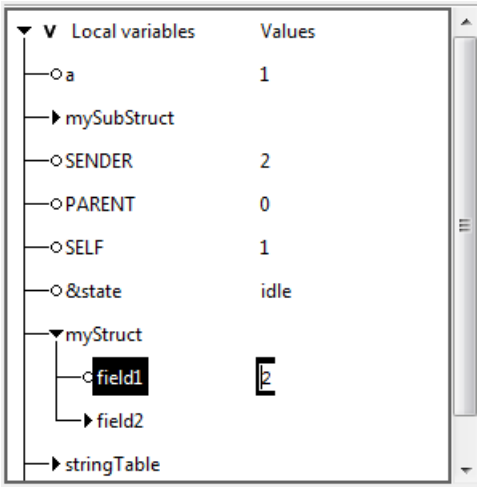


Local variables example

Some key variables are always present:

- OFFSPRING
  SDL keyword indicating the pid of the last process created dynamically within the current process; 0 if none have been created.
- SELF
  SDL keyword indicating the current process pid.
- PARENT
  SDL keyword indicating the pid of the process that created the current process; 0 if the process was created statically at startup.
- SENDER
  SDL keyword indicating the pid of the sender of the last received message.
- &state
  Internal variable representing the current state of the process.

The *SDL simulator Local variables* window also allows to modify the value of variables. To do so double click on the variable value. Press `<Return>` and the value is updated.



Setting a local variable value example

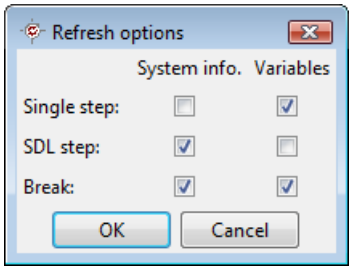
6.3.5.6 Refresh options

The information displayed in the SDL simulator windows are divided in 2 categories:

- System info
  - Process information
  - Timer information
  - Semaphore information
- Variables
  - Local variables
  - Watch variables

Retrieving any information from the target is time consuming. In order to optimize the response time it is possible to configure which category of information is refreshed.

The configuration is done in the *Options / Refresh options...* menu.



Default Refresh options

- Single step means the use of one of the following step button: ,

  In the default options, only the Variables category is refreshed since there is no reason the System information category has changed in the meantime.

- SDL step means the use of step button,

  When stepping from an SDL event to another, only the System information category is interesting to update.

- Break means the system has hit a breakpoint.
  In that case it is recommended to update all the information.

Anyway, at any time it is possible to refresh all information :

6.3.6 Shell

The SDL simulator shell allows to enter all commands listed above and is used as a textual trace.

The available commands are grouped in categories. To list all the available categories type:

`help`

It will list the following categories:

```
Type help followed by a category to list available commands
-----------------------------------------------------------
  shell
  execution
  interaction
  variables
  trace
  customization
```

Type help followed by a category name to list the corresponding commands.

To list all the available commands, type:

`h`

It will list the following commands:

```
Command       - Explanation
-----------------------------
h             - lists all commands
history       - list the last entered valid commands
clear         - clears the shell
echo <string> - echos a string in the shell
include <file name>
resume        - resumes the scenario
repeat <repeat count> <shell command> [|; <shell command>]*
# <comment>
! <any host command>
refresh       - refreshes all data in the window
run           - runs the SDL system
stop          - stops the SDL system
step          - step in the code
stepin        - step in function calls
```

```
stepout       - step out a function call
keySdlStep    - run until the next key SDL event
sdlTransition - run until the end of the SDL transition
runUntilTimer - run all transitions until timers
list          - list breakpoints
watch add [<pid>:]<variable name>[<field separator><field name>]*
watch del [<pid>:]<variable name>[<field separator><field name>]*
break <break condition> [<ignoreCount> <volatile>]
delete <breakPoint number>
db <any debugger command>
set time <new time value>
send2name <sender name> <receiver name> <signal number or name> [<parameters>]
send2pid <sender pid> <receiver pid> <signal number or name> [<parameters>]
sendVia <sender pid> <channel or gate name> <signal number or name> [<parameters>]
send <sender pid> <signal number or name> [<parameters>]
systemQueueSetNextReceiverName <receiver name>
systemQueueSetNextReceiverId <receiver id>
extractCoverage <file name>
connect <port number>
connectxml <port number>
disconnect
varFromType <variable name> <variable type>
varFromValue <variable name> = <initial value>
varFieldSet <variable name>[.<field name>]* = <field value>
dataTypes <on | off>
print <variable name>
sdlVarSet [<process id>:]<variable name>=<value>
sdlVarGet [<process id>:]<variable name>=<value>
backTrace     - display last events traced when activated in profile
setupMscTrace <time information> <message parameters> [<agents>]
startMscTrace
stopMscTrace
saveMscTrace <file name>
setEnvInterfaceFilter 1|0
buttonWindowCreate <button window name>
buttonWindowAdd <button window name> <button name> = <shell command> [|; <shell command>]*
buttonWindowDel <button window name> <button name>
buttonWindowLabelAdd <button window name> <label name>
buttonWindowLabelDel <button window name> <label name>
-----------------------------
In any of the shell commands the following can be used:
|$(<os environment variable>) to acces an operating system environment variable
|${<interactive label>} pops up an interactive window to get variable value, /s, /b and others can be used
```

```
|$[<shell variable name>] will be replaced by the shell variable value
|$<<process name>:<instance number>> will be replaced by the pid of the instance of the process
& <any command> will prevent the above pre-processing
<partial command>\ and continue the command on the next line of the shell
```

The last valid commands can be recalled with the upper arrow.

Some of these commands are the equivalent to buttons in the button bar. Some are specific to the shell and will befurther explained below.

6.3.6.1 shell commands

To list all the available commands in this category, type:

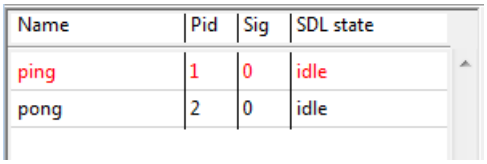
`help shell`

It will list the following commands:

```
Command       - Explanation
---------------------------
h             - lists all commands
history       - list the last entered valid commands
clear         - clears the shell
echo <string> - echos a string in the shell
include <file name>
  run a scenario of commands out of a file
resume        - resumes the scenario
repeat <repeat count> <shell command> [|; <shell command>]*
  repeat a set of shell commands
# <comment>
  does nothing
! <any host command>
  runs any host command
-----------------------------
In any of the shell commands the following can be used:
|$(<os environment variable>) to acces an operating system environment variable
|${<interactive label>} pops up an interactive window to get variable value, /s, /b and others can be used
|$[<shell variable name>] will be replaced by the shell variable value
|$<<process name>:<instance number>> will be replaced by the pid of the instance of the process
& <any command> will prevent the above pre-processing
<partial command>\ and continue the command on the next line of the shell
```

- Running scenarios
  A set of commands can be saved to a script file with the red circle button in the tool bar. The include command or the play button allows to run a script file. The script file is stopped when a breakpoint is hit or when the stop button is pressed. Type the resume command to resume the scenario.
- Process instances pid
  It is possible to get a process instance pid with the `|$< <process name> >` syntax.

Example:
In the following configuration:



`echo |$<pong:0>`
echos the pid of the first instance of pong:
`2`
Note:
This feature does not work if the *Free run* option is activated.

- Environment variables
  Operating system environment variables can be accessed with the `|$(<variable name>)` syntax.
  Example:
  `echo |$(RTDS_HOME)`
  echos:
  `C:\RTDS`

6.3.6.2 execution commands

To list all the available commands in this category, type:
`help execution`

It will list the following commands:

```
Command       - Explanation
--------------------------
refresh       - refreshes all data in the window
run           - runs the SDL system
stop          - stops the SDL system
step          - step in the code
stepin        - step in function calls
stepout       - step out a function call
keySdlStep    - run until the next key SDL event
sdlTransition - run until the end of the SDL transition
runUntilTimer - run all transitions until timers
list          - list breakpoints
watch add [<pid>:]<variable name>[<field separator><field name>]*
  adds a variable to watch:
  <pid> is the process id in which the variable is. Only available in Z.100 simulation.
  <variable name> is the name of the variable
  <field separator> is '!' in SDL Z.100 or '.' in SDL-RT
  <field name> is the name of the variable field or sub-field
watch del [<pid>:]<variable name>[<field separator><field name>]*
  remove a variable to watch
```

```
  <pid> is the process id in which the variable is. Only available in Z.100 simulation.
  <variable name> is the name of the variable
  <field separator> is '!' in SDL Z.100 or '.' in SDL-RT
  <field name> is the name of the variable field or sub-field
break <break condition> [<ignoreCount> <volatile>]
  break condition is a function name or '*'break address or filename':'linenumber  ignoreCount is a number
  volatile is a boolean: 'true' or 'false'
delete <breakPoint number>
db <any debugger command>
  the command is directly sent to the debugger with no verification
```

- `db`
  This command is not effective in SDL Z.100 simulation.

6.3.6.3 interaction commands

To list all the available commands in this category, type:
`help interaction`

It will list the following commands:

```
Command       - Explanation
---------------------------
set time <new time value>
  new time value can be absolute time or '+'delta
send2name <sender name> <receiver name> <signal number or name> [<parameters>]
send2pid <sender pid> <receiver pid> <signal number or name> [<parameters>]
sendVia <sender pid> <channel or gate name> <signal number or name> [<parameters>]
send <sender pid> <signal number or name> [<parameters>]
  environment name is 'RTDS_Env' and environment pid is '-1'
  parameters are |{field1|=value|,field2|=value|,...|}
systemQueueSetNextReceiverName <receiver name>
systemQueueSetNextReceiverId <receiver id>
extractCoverage <file name>
connect <port number>
  to connect to an external tool on a socket using the shell format
connectxml <port number>
  to connect to an external tool on a socket using the xml-rpc format
disconnect
  to disconnect from the external tool
```

- `set time`
  This command sets a new system time value if the debugger allows it. Please check the reference manual for more information.
- `connect`

This command opens a socket in server mode to connect an external tool to the *SDL simulator shell*. The parameter is the port number on the host IP address. This command should be done before starting the client.

- `disconnect`
  Disconnect the socket from the external tool.
- System queue manipulation
  It is possible to re-organize the system queue order from the shell. The `systemQueueSetNextReceiverName` will put up front in the system the next message for the defined receiver name, and `systemQueueSetNextReceiverId` will put up front in the system queue the next message for the defined receiver pid.
- `extractCoverage`
  Extracts the code coverage for the current debug session so far and stores it in the specified file. If the file name is relative, it will be taken from the project directory. Please note that if this command is used in a debug session run via the `rtdsSimulate` command line utility, the project will be saved in the end and the code coverage results stored in it.

6.3.6.4 variables commands

To list all the available commands in this category, type:
`help variables`

It will list the following commands:

```
Command       - Explanation
---------------------------
varFromType <variable name> <variable type>
  creates a variable of the given type to be used in the shell
varFromValue <variable name> = <initial value>
  creates a variable with the given initial value to be used in the shell
varFieldSet <variable name>[.<field name>]* = <field value>
  sets a single variable field to a given value
dataTypes <on | off>
  prints the type of the variable
print <variable name>
  prints the variable value
sdlVarSet [<process id>:]<variable name>=<value>
sdlVarGet [<process id>:]<variable name>=<value>
```

- shell variables
  It is possible to define variables in the shell and to use them in send2xxx commands using the `|$(<variable name>)` syntax..
  - `varFromType`
    This command allows to declare a variable based on a type defined in the SDL system. Only the types used as parameters in messages are available. The message parameters need to be defined in a super-structure in order to be compliant with the executor.

Example:

```
SIGNAL mDummy(t_SubStruct, t_Struct);

NEWTYPE t_SubStruct
  STRUCT
    subField1   Real;
    subField2   Boolean;
ENDNEWTYPE;

NEWTYPE t_Struct
  STRUCT
    field1  integer;
    field2  charstring;
    field3  t_SubStruct;
  OPERATORS
    myEcho: charstring->charstring;
    echo2: integer,charstring, t_SubStruct->charstring;
    myPower: integer->integer;
    myMultiply: integer, integer->integer;
ENDNEWTYPE;
```

Shell commands to define a variable based on the type:

```
>varFromType a t_SubStruct
>print a
|{subField1|=0.0|,subField2|=0|}
>varFieldSet a.subField1=3.14
>varFieldSet a.subField2=1
>print a
|{subField1|=3.14|,subField2|=1|}
>varFromType b t_Struct
>varFieldSet b.field1=666
>varFieldSet b.field2=Hello world
>varFieldSet b.field3.subField1=6.55957
>varFieldSet b.field3.subField2=0
>print b
|{field1|=666|,field2|=Hello
world|,field3|=|{subField1|=6.55957|,subField2|=0|}|}
>send2name pPing normal mDummy |{param1|=|$(a)|,param2|=|$(b)|}
send2name pPing NORMAL_SIGNAL mDummy
|{param1|=|{subField1|=1.23|,subField2|=0|}|,param2|=|{field1|=666|,field2|=
Hello world|,field3|=|{subField1|=6.55957|,subField2|=0|}|}|}
>Signal: mDummy sent by: RTDS_Env(-1) at: 0  ticks
>{param1={subField1=1.23,subField2=0},param2={field1=666,field2=Hello
world,field3={subField1=6.55957,subField2=0}}}
>
```

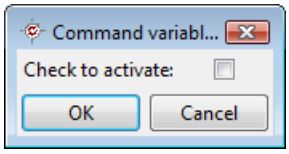
- `varFromValue`
  This command allows to declare an untyped variable based on its value. Shell commands to define a variable based on its values:

```
>varFromValue c=|{subField1|=1.23|,subField2|=0|}
>varFromType b t_Struct
>varFieldSet b.field1=666
>varFieldSet b.field2=Hello world
>varFieldSet b.field3.subField1=6.55957
>varFieldSet b.field3.subField2=0
>print b
|{field1|=666|,field2|=Hello
world|,field3|=|{subField1|=6.55957|,subField2|=0|}|}
```

```
>send2name pPing normal mDummy |{param1|=|$(c)|,param2|=|$(b)|}
send2name pPing NORMAL_SIGNAL mDummy
|{param1|=|{subField1|=3.14|,subField2|=1|}|,param2|=|{field1|=666|,field2|=
Hello world|,field3|=|{subField1|=6.55957|,subField2|=0|}|}|}
>Signal: mDummy sent by: RTDS_Env(-1) at: 0  ticks
>{param1={subField1=3.14,subField2=1},param2={field1=666,field2=Hello
world,field3={subField1=6.55957,subField2=0}}}
>send2name pPing normal mDummy |{param1|=|$(c)|,param2|=|$(b)|}
send2name pPing NORMAL_SIGNAL mDummy
|{param1|=|{subField1|=1.23|,subField2|=0|}|,param2|=|{field1|=666|,field2|=
Hello world|,field3|=|{subField1|=6.55957|,subField2|=0|}|}|}
>Signal: mDummy sent by: RTDS_Env(-1) at: 0  ticks
>{param1={subField1=1.23,subField2=0},param2={field1=666,field2=Hello
world,field3={subField1=6.55957,subField2=0}}}
>
```

- `varFieldSet`
  This command sets a field of the variable. This can only be used on simple type fields.
- `print`
  This command prints a variable value.

- `dataTypes`
  This command is a verbose mode that displays the type when printing data.
- Accessing variables
  - Shell variables
    RTDS debugger shell variables can be accessed with the `|$[<variable name>]` syntax.
    Example:
    ```
    varFromType myVar mySubStructType
    print myVar
    |{b|= |,a|=0|}
    echo |${myVar}
    ```
    echos:
    ```
    |{b|= |,a|=0|}
    ```
  - Interactive variables
    It is possible to ask the user for a value with the `|${<input label>}` syntax. Options for the input label are: For strings, the only option is its length (default: 20). For booleans, options are the value when checked and the value when
    unchecked, separated by a comma. For example, a field with type "b[-r,]" will be
    replaced in the command by "-r" if the user checks the corresponding check-box, and
    by the empty string otherwise. The defaults are "1" for checked and "0" for unchecked.
    Example:
    ```
    echo |${Check to activate: /b}
    ```
    pops up the following window:



echos 1 if checked or 0 if unchecked.

6.3.6.5 trace commands

To list all the available commands in this category, type:
`help trace`

It will list the following commands:

```
Command       - Explanation
---------------------------
backTrace     - display last events traced when activated in profile
setupMscTrace <time information> <message parameters> [<agents>]
  sets up the MSC trace where:
  <time information> is 0 or 1
  <message parameters> is 0 or 1
  <agents> is the list of agent names to trace separated by spaces
startMscTrace
stopMscTrace
saveMscTrace <file name>
setEnvInterfaceFilter <filter status>
  <filter status> is 1 or 0, when active only messages with the environment will be traced
```

- MSC trace
  The MSC trace can be configured, started, stopped, and saved from the shell.
  Example:
  `setupMscTrace 0 1 pPing`
  Will only trace pPing instance with no time information but with parameters.
- Filtering the interface between the environment and the system
  The `setEnvInterfaceFilter` command allows to filter out SDL events that are not related to the interface of the system at a very low level in the SDL simulator. This feature should be used to increase simulation speed and when internal information is not needed.

6.3.6.6 customization commands

To list all the available commands in this category, type:
`help customization`

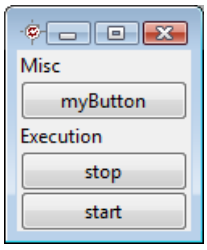
It will list the following commands:

```
Command       - Explanation
---------------------------
buttonWindowCreate <button window name>
  creates a window to contain user defined buttons
buttonWindowAdd <button window name> <button name> = <shell command> [|; <shell command>]*
  adds a button to previously created button window
  <button window name> is the name of the button window
  <button name> is the text to be displayed on the button
```

```
  <shell command> is the command associated with the button
buttonWindowDel <button window name> <button name>
  removes a button from a button window
  <button window name> is the name of the button window
  <button name> is the text of the button to be removed
buttonWindowLabelAdd <button window name> <label name>
  adds a label to previously created button window
  <button window name> is the name of the button window
  <label name> is the text to be displayed on the label
buttonWindowLabelDel <button window name> <label name>
  removes a label from a button window
  <button window name> is the name of the button window
  <label name> is the text of the label to be removed
```

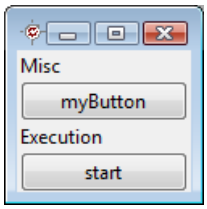
- Button windows
  It is possible to create user-defined buttons and to associate shell commands.
  Here is an example of a button window:

```
>buttonWindowCreate myWindow
>buttonWindowLabelAdd myWindow Misc
>buttonWindowAdd myWindow myButton = help
>buttonWindowLabelAdd myWindow Execution
>buttonWindowAdd myWindow stop = send2name pPing normal
mStop
>buttonWindowAdd myWindow start = send2name pPing normal
mStart |{param1|=12345|}
```



So clicking on myButton will actually execute the help command in the shell.
It is also possible to remove labels or buttons:

```
>buttonWindowDel myWindow stop
```



It is possible to create several button windows.
To stop one of the window, just close the window.

6.3.7 Status bar

The status bar is divided in two parts:

- The *SDL simulator* internal state
  The *SDL simulator* can have the following internal states:

State	Meaning
`STOPPED`	The system is stopped
`STOPPING`	The system is trying to stop. No commands are allowed in that intermediate state.
`RUNNING`	The system is running. The traces might be active or not (Options / Free run). A stop is possible in that state.
`STEPPING`	C code classical stepping. Note a classical step might take a lot of time. A stop is possible in that state.
`KEY_SDL_STEPPING`	Step to the next SDL key event. Note an SDL step might take some time. A stop is possible in that state.
`SDL_TRANSITION`	Step until the end of the SDL. Note an SDL step might take some time. A stop is possible in that state.
`ERROR`	An error has occurred and the SDL simulator is stuck. Restart the SDL simulator.

Table 3: SDL simulator internal states

- The active thread
  The active thread is displayed in the right part of the status bar when known.

6.3.8 Breakpoints

6.3.8.1 Setting breakpoints

Breakpoints are set in the SDL editor. Select an SDL symbol and click on quick button to set a simple breakpoint. Breakpoint options are available in the *Set breakpoint* window through *Debug / Set breakpoint...* menu:

- on which line the breakpoint should be set in the symbol,
- if the breakpoint is volatile or not,
- if there should ignoreCount on the breakpoint.

6.3.8.2 Listing breakpoints

The breakpoints set can be listed in the *SDL simulator shell* with the `list` command.

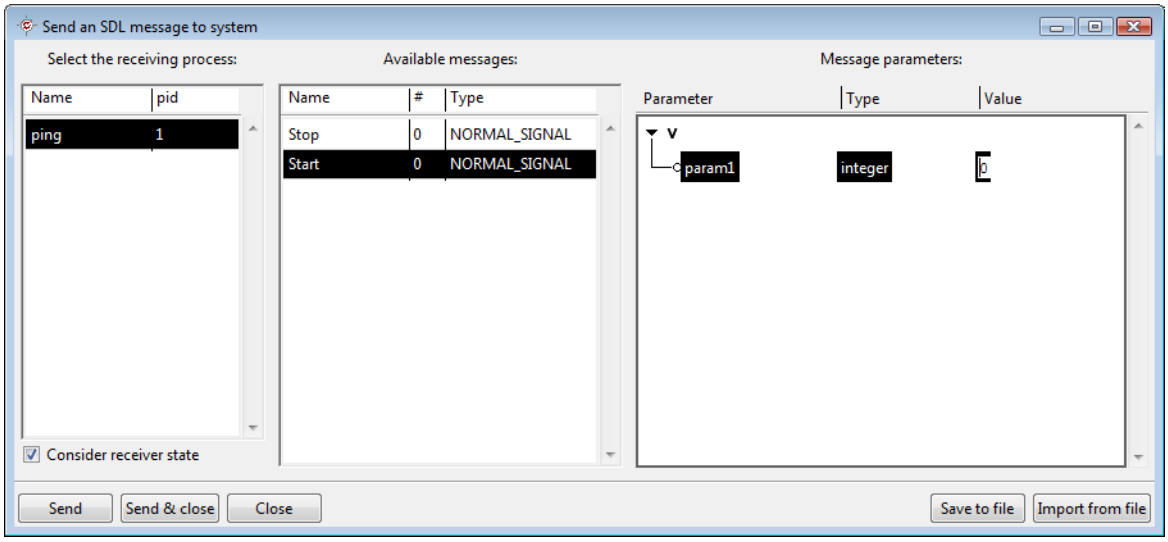
6.3.8.3 Deleting breakpoints

Breakpoints can be deleted from:

- the shell with the delete command:
  `delete <breakpoint number>`
  where the `breakpoint number` is the number listed from the `list` command.
- the text editor as to set one,
- the SDL editor as to set one.

6.3.9 Sending SDL messages to the running system

The *SDL simulator Send SDL message* button opens the *SDL message send* window. It will list the possible senders and receivers, and the available messages in the system:



The SDL message send Window

An equivalent command can be found in the shell:

```
send2pid <sender pid> <receiver pid> <signal number or name> [<parameters>]
```

where `signal type` can be `normal` or `timer`, or:

```
send2name <sender name> <receiver name> <signal number or name> [<parameters>]
sendVia <sender pid> <channel or gate name> <signal number or name> [<parameters>]
send <sender pid> <signal number or name> [<parameters>]
```

Verifications are made on the sender pid and receiver pid only.

Structured parameters are updated and displayed at the right of the window when selecting a signal. The equivalent format for the shell command depends on whether the message is structured or not. Structured parameters are fully described in RTDS Reference Manual. In short, a message is structured if and only if it is declared with several parameters or with one parameter that is a pointer to a struct or a union.

- For a non-structured message, the text for the parameter must be a sequence of bytes written in hexadecimal format, exactly as they will appear in the target program memory.
- For a structured message, the text for the parameter must be written as follows:
  - The values for base types are written as in C: for example `12` or `871` are valid values for an `int`, `X` is a valid value for a `char`, and so on...

- The values for structs or choices are coded as follows:
  `|{field1|=value|,field2|=value|,...|}`
  For example, for a struct defined as:
  `MyStruct STRUCT { i integer; s charstring; };`
  a valid format is:
  `|{i|=4|,s|=|:abcd|}`
  In the struct created on the target, the field `i` will be set to `4` and the field `s` will be set to `"abcd"`.
  Please note that what is significant in the formatted text is not the field names, but the field order; so in the example above, you can't write:
  `|{s|=|:abcd|,i|=4|}/* INVALID! */`
  As a consequence, the field names are in fact optional, so you can write:
  `|{|=4|,|=|:abcd|}`
  Please also note that if no value is specified for a field, the field is left as is. This can be used to set the value for fields in a choice. For example, for:
  `CHOICE MyChoice { i integer; c character; };`
  a valid format is:
  `|{i|=|,p|='a'|}`
  The field `i` won't be set and the field `p` will be set to `'a'`.
- Escape sequences
  Use a `||` to introduce a `|` in the message parameters,
  Use a `|.` to introduce a carriage return in the message parameters.

6.3.10 Connecting an external tool

It is possible to connect an external tool to the *SDL simulator* through a socket. To allow connections to the *SDL simulator* the `connect` command should be entered in the *SDL simulator shell*:

```
connect <port number>
```

The IP address used is the IP address of the host where the *SDL simulator* is running. Only the port number can be configured.

The *SDL simulator* is seen as a server so the connect command should be executed before starting the client.

Once the connection is made the client has basically a direct access to the shell commands: whatever is sent goes to the *SDL simulator shell* and whatever the shell replies goes to the socket. Therefore the syntax is the one used in the shell. Note the external tool connected will also receive any information that is printed out in the shell.

To close the socket use the `disconnect` command in the *SDL simulator shell*.

Here is a sample code in Python (http://www.python.org) that connects to port 50010:

First start the server in the *SDL simulator shell*:

```
connect 50010
```

Then go to a shell or DOS window and type:

```
python
>> from socket import *
>> s=socket(AF_INET, SOCK_STREAM)
```

```
>> s.connect((gethostname(), 50010))
>> s.send('help\n')
>> print s.recv(500)
```

It will print out the 500 first characters of the *SDL simulator* help and display it in the *SDL simulator shell*.

6.3.11 Command line simulation

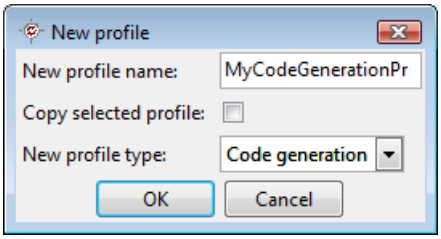
The Simulator can be started from a shell or a DOS console and run an execution script automatically with the `rtdsSimulate` command. Check the Reference manual for more information.

6.4 - SDL Z.100 Code generation

An SDL Z.100 system can be generated to C code, integrated with an RTOS, and graphically debugged with one of the supported debuggers.

The SDL Z.100 to C code generation translation rules are explained in the SDL to SDL-RT conversion chapter of the Reference Manual.

C code is generated with a code generation profile. When creating a new profile a pop up window will ask if the profile is for simulation or code generation:



Select “Code generation” and fill in the options as explained in the “Profiles” on page 133.

The graphical debugger architecture and features are described in “SDL-RT debugger” on page 187.

6.5 - Verifying a SDL system

6.5.1 Scope

SDL Z.100 systems can be translated to IF descriptions as specified by *Verimag*. The translation rules and restrictions can be found in the Reference Manual. Tools based on IF technology allow:

- Exhaustive simulation,
- Test generation.

The IFx toolbox has to be downloaded on Verimag website: http://www-if.imag.fr/. The Python language interpreter will be required too; it be found at http://www.python.org/.

Rules to be verified during exploration are described in IF observers. Each time a transition is executed in the system, the IF observer verifies its internal rules. Whenever a rule is verified or violated, it is possible to generate an MSC or a test case.

6.5.2 IF Observers

Rules verified during the state space exploration are described by observers.

An observer file can be directly had to a project, or inside a folder, by choosing "Add component...' in the contextual menu. Many observers can be added, and used to test the system.

Observers are processes that can view everything that happens in the system. They are evaluated each time the system reaches a new state. They can verify:

- Static rules such as the value of variables,
- Dynamic rules such as a sequence of events.

Observers can define variables, handle timers, and evaluate expressions.

Observers, as supported in RTDS, look like SDL processes but they are not SDL processes. The syntax of the statements is based on IF language, and it does not have any message queue by default.

6.5.2.1 Types of Observers

There are three types of Observers:

- pure
  That type is the most basic one, it can not interfer with the system nor with the exploration.
- cut
  This is the most common type of observers, it can not interfer with the system but it can interfer with the state exploration. A typical behaviour is to stop exploration (cut) in a branch that is not of interest.
- intrusive
  The observer can interfer with the state exploration and it can modify the system itself: send signals and modify variables.

The type of Observer is indicated in the declaration symbol:

6.5.2.2 Data types in Observers

The following basic data types are available in IF: *integer*, *real*, *boolean*, *pid*, *clock*.Character and charstring are replaced by RTDS_charstring, which is a string of integers which holds the ASCII value of each character. To define the value of a charstring, it is required to define the ASCII code of each element and concatenate all these elements with the symbol ^.

For example, for a charstring *c* equal to *"toto"*:

```
var c RTDS_charstring;
task c := RTDS_charstring(116) ^ RTDS_charstring(111) ^
RTDS_charstring(116) ^ RTDS_charstring(111);
```

The following constructs are also available:

Table 4: IF constructs

Constructs	Declaration	Usage
const	const MyConst=3;	var v integer; task v := MyConst;
var	var v integer; var c clock;	var v integer; task v := 2;
enum	type MyType = enum red, green, blue endenum;	var v MyType; task v := green;
record	type MyRecord=record FirstField integer; SecondField boolean; endrecord;	var v MyRecord; task v.FirstField := 3;
range	type MyRange=range 0..4;	
array	type MyArray=array[4] of integer;	var v MyArray; task v[3] := 5;

Table 4: IF constructs

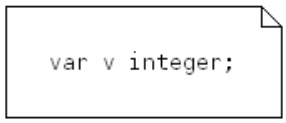
Constructs	Declaration	Usage

string	type MyString=string[5] of integer;
	var v MyString
		var v MyString;
		var w MyString;
		var x MyString;
		var position integer;
		const value = 7;
		task position := length(v);
		task v := insert(v, position, value);
		task w := remove(v, position);
		task x := v^w; // concatenate

while	while (<condition>) do
	<statements>;
	endwhile;
		while (i<4) do
		output sig1;
		task i:=i+1;
		endwhile

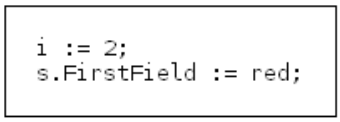
if	if (<condition>) then
	<statements>;
	else
	<statements>
	endif;
		if (i<4) then
		output sig1;
		else
		output sig2;
		endif

Variables are declared in the text symbol:

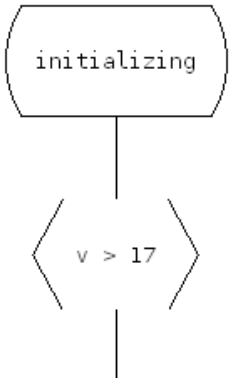


Variables are manipulated in:

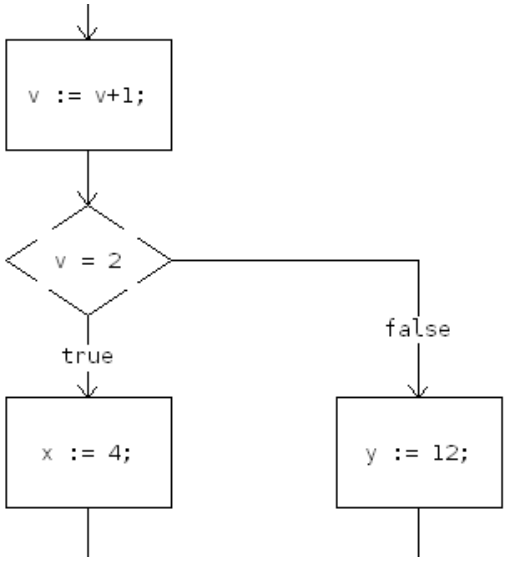
- Action symbols



- Provided symbols



- Decision symbols

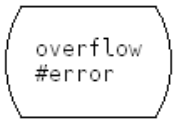


6.5.2.3 Action symbols in Observers

The Observer process starts with the Start symbol, can go through a number of states, and can be ended with the Stop symbol.

6.5.2.3.1 States

There are three types of states: ordinary, error, and success. The type of state is written below the state name with a hash:

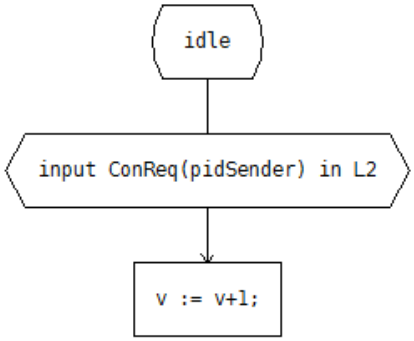


By default the state is considered ordinary.

6.5.2.3.2 Triggers

Three possible events can trigger the state: *match*, *provided*, *when*.

A match statement is described as a closed continuous signal SDL symbol:



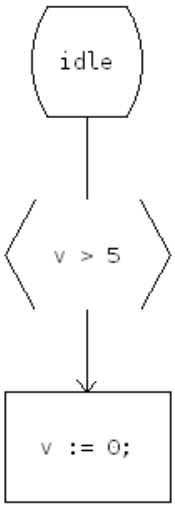
In this example, pidSender has previously been declared like a pid.

The possible match statements are:

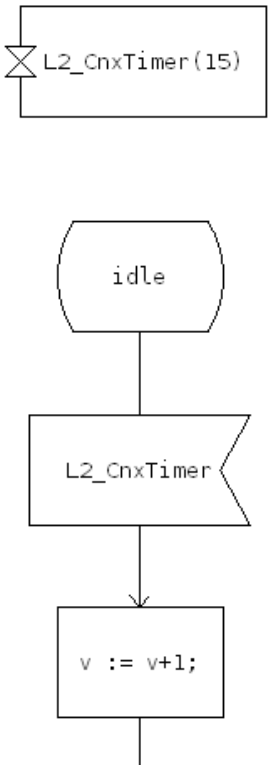
- match `input <sig(sender pid, params)> in <pid>`
- match `output <sig(sender pid, params)> from (<pid>) via (<channel>) to (<pid>)`
- match `fork(<pid>) in <pid>`
- match `kill(<pid>) in <pid>`
- match `<deliver>`
- match `informal "my text" in (<pid>)`

The match keyword is omitted in the graphical symbol.

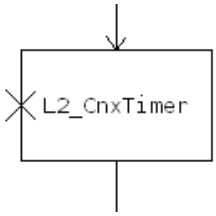
A provided statement is described with the SDL continuous signal symbol:



A when statement is described with the SDL start timer symbol to start the clock, and an input symbol:

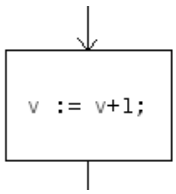


A timer can also be cancelled with the SDL cancel timer symbol:



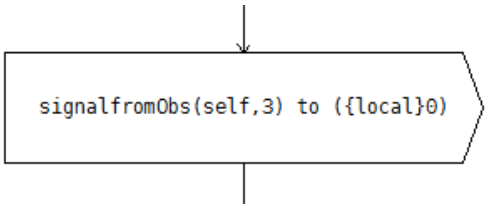
6.5.2.4 Statements

Any IF statement can be written in the SDL action symbol:



6.5.2.5 Output

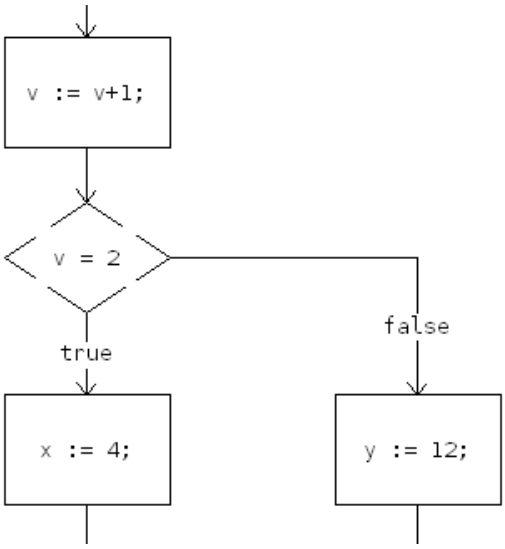
An IF intrusive observer is able to send signals to any process of the system, but can not receive any sygnal:



self has always to be add as first paramater for an output in an observer.

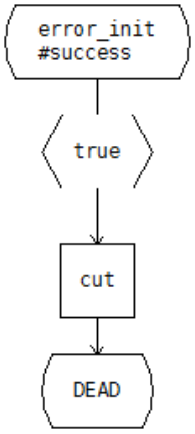
6.5.2.6 Decisions

Decisions are handled with unstable states in IF. It uses the SDL decision symbol:

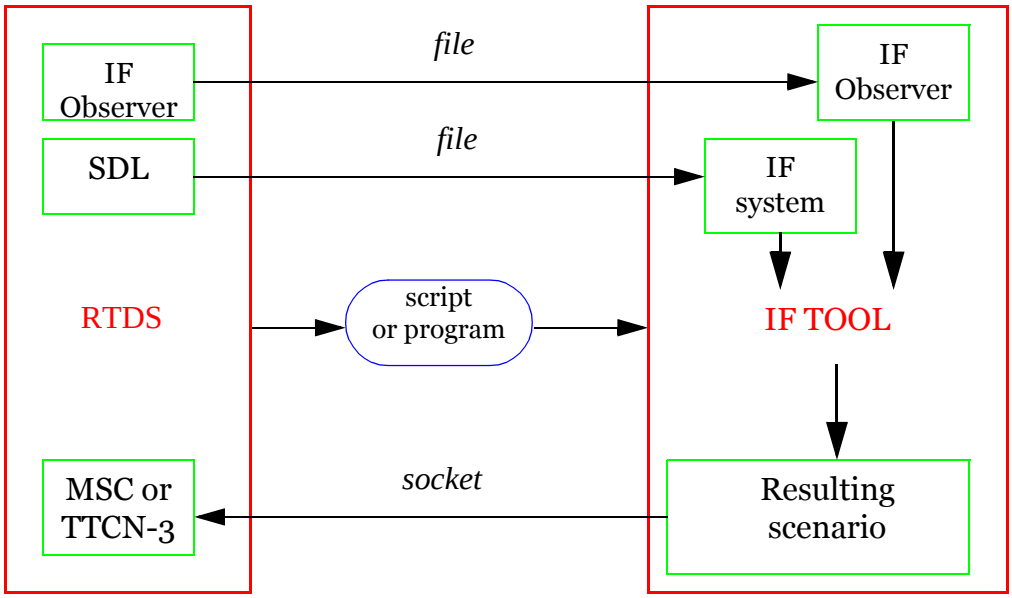


6.5.2.7 Reducing state space

Exploration in the current branch can be stopped with the IF *cut* statement in an action symbol. Please note the `#success` or `#error` states do not stop exploration of the system. An explicit `cut` action should be used afterwards in order to stop exploration.

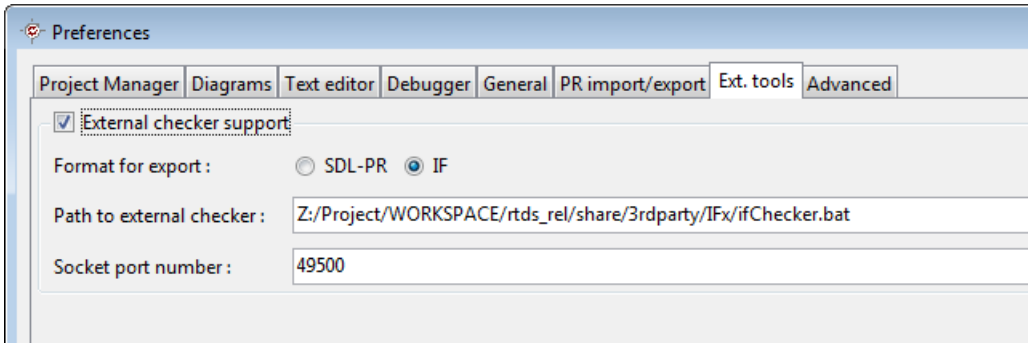


6.5.3 General architecture



The SDL system can simply be exported to an IF file, or a full verification process can be automated from RTDS. In that case, after exporting an SDL model to IF language, RTDS calls a script -which probably calls an IF tool on the IF description- and opens a socket waiting for an MSC trace file.

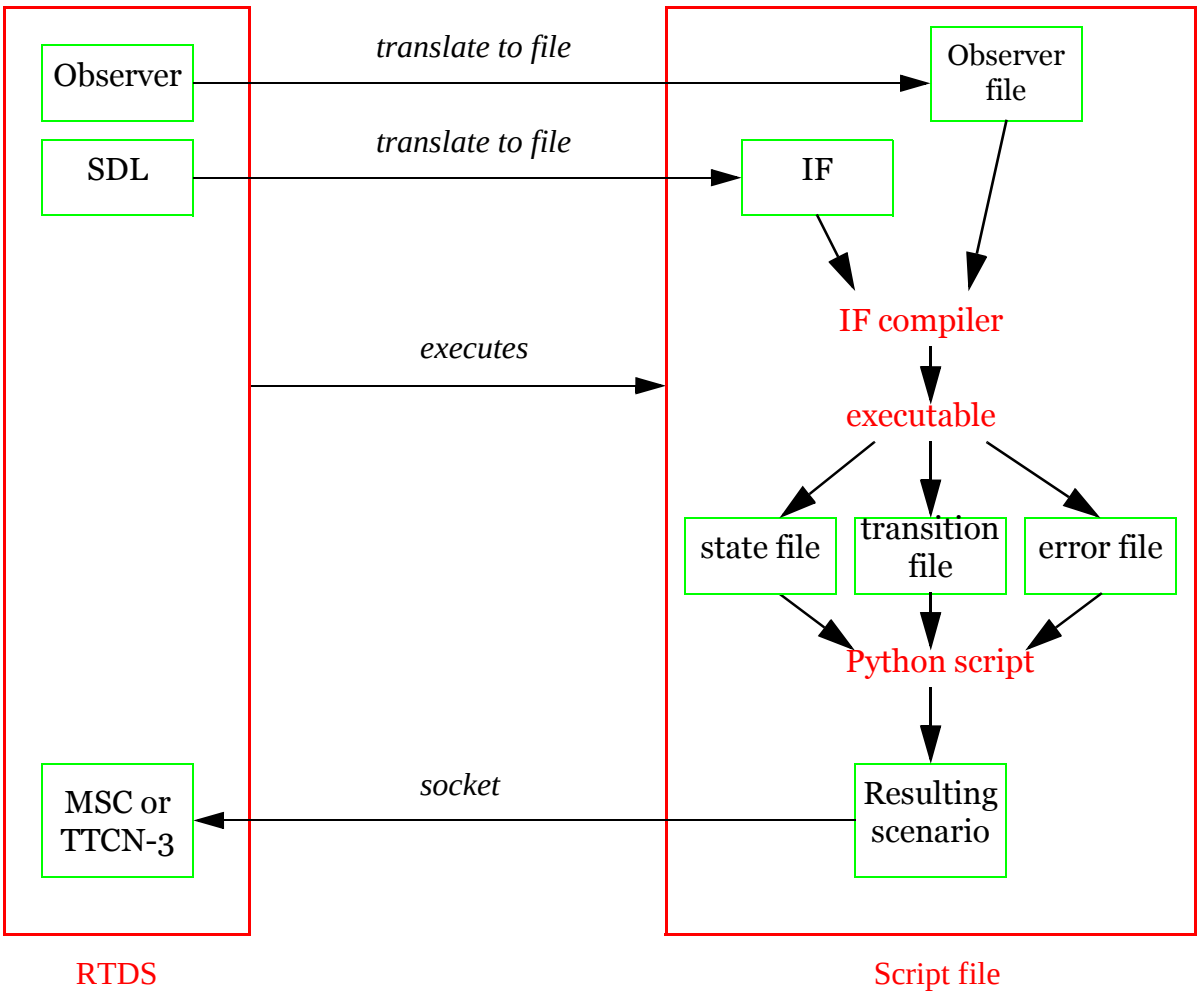
The script or the external executable can be customized as well as the socket port number to use via the menu *File -> Preferences* and the *Ext. tools* tab:



As the current directory is not specified, the executed script should not depend on where it is executed. The MSC Trace file format is the one described in the MSC Tracer documentation.

6.5.4 Example script for Verimag IFx toolset

An example script for the external model checker is delivered with RTDS. This script uses the IFx toolkit from Verimag. This script works as described in the following diagram:

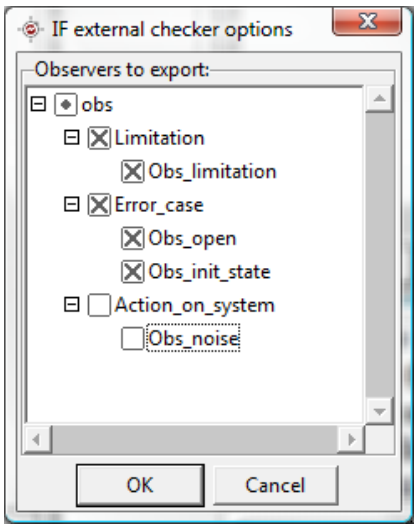


The script can be found in the sub-directory `share/3rdparty/IFx/ifChecker.sh` of the RTDS installation directory. It requires an IF observer to specify the properties to check in the SDL system. This observer is specified via the environment variable `RTDS_IF_OBSERVER`, which must contain the full path to the observer file.

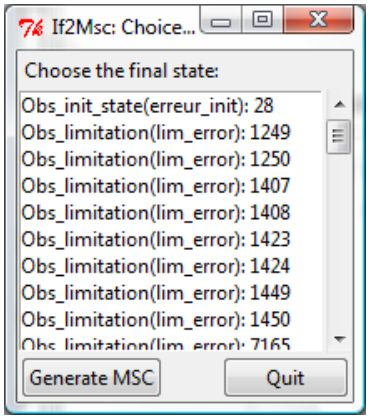
Once RTDS is configured as described in the previous section and the environment variable has been set, calling "External model checker" from the "Tools" menu in the project manager will successively:

- Export the current project as an IF file;

- Select the observers to test the system. If observers are inside folder, it is possible to select every observers by selecting the folder;



- Run the IFx compiler on this file and the observer file, which will produce an executable;
- Run this executable to actually perform the simulation;
- Get the output from the execution and pass it to a Python script which will analyse the errors if any. This script displays the following window if the simulation have found some scenarios that invalidate the conditions:



The numbers displayed are the internal numbers for the global system states identified as errors by the IFx toolkit. For each state number are displayed the name of the observer which has stoped the system and the corresponding error state name.
Generating a MSC for the scenario leading to a given error state is done by selecting the state number in the list and pressing the "Generate" button. RTDS should then display a dialog telling that an external MSC has been generated and validating it should open the diagram in the MSC editor window.

7 - TTCN-3 support

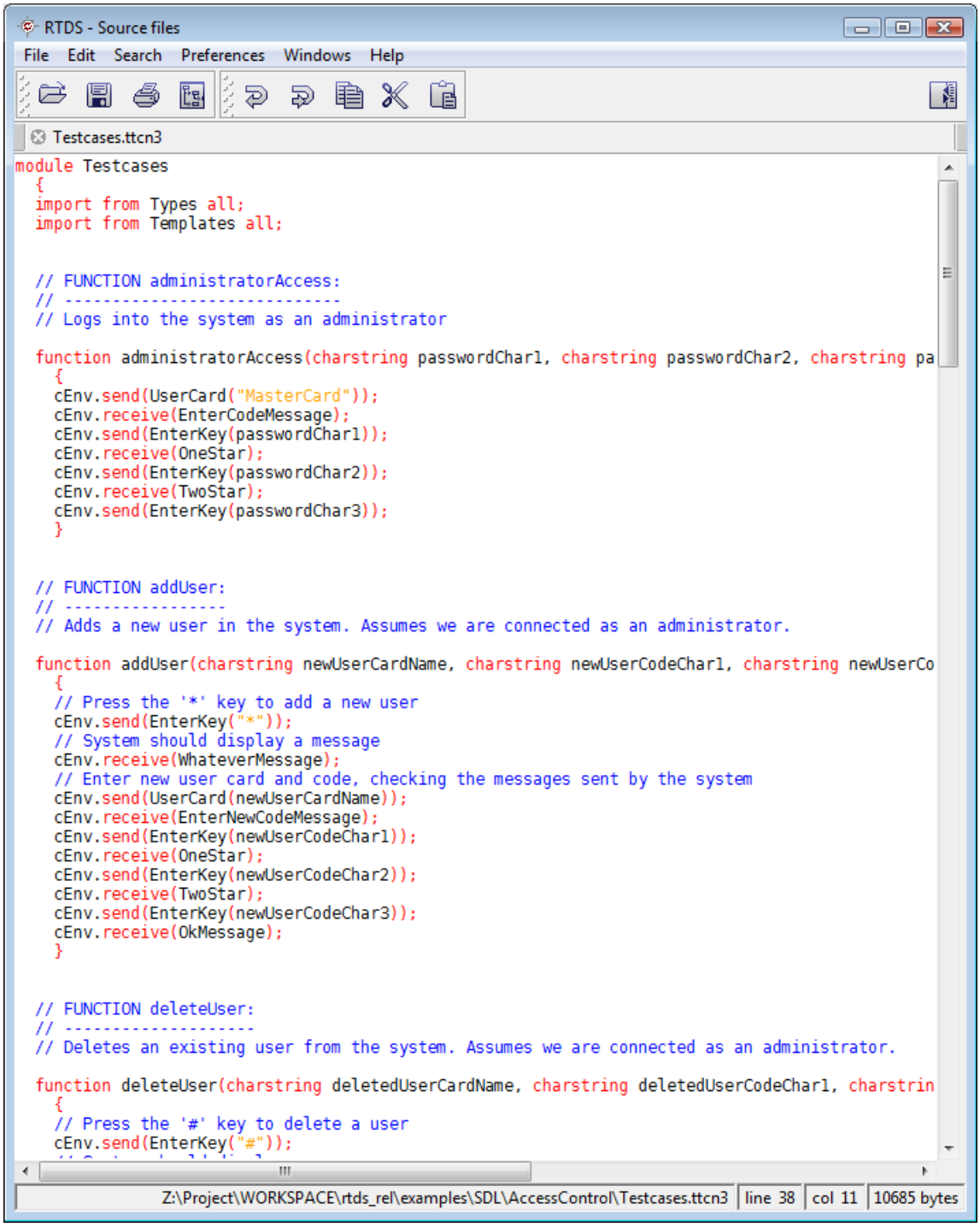
7.1 - Levels of support

RTDS supports TTCN-3 test suites in both the editors and the simulator:

- Source files in TTCN-3 core language can be included in a project.
- Full syntax coloring and checking is available for these files.
- TTCN-3 test suites can be simulated in the SDL simulator along with the system they test.

7.2 - TTCN-3 core language file editor

TTCN-3 core language source files can be included in RTDS projects and edited with the included text editor:

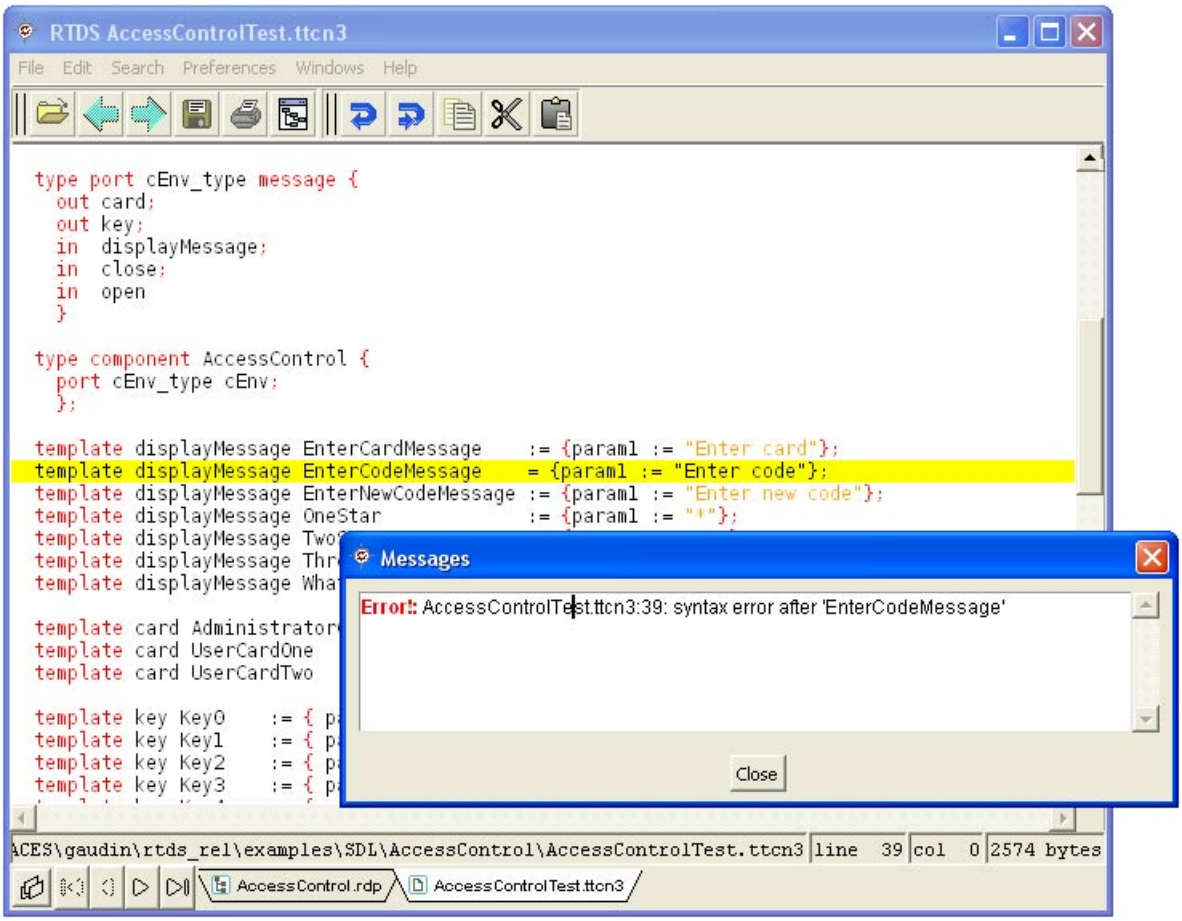


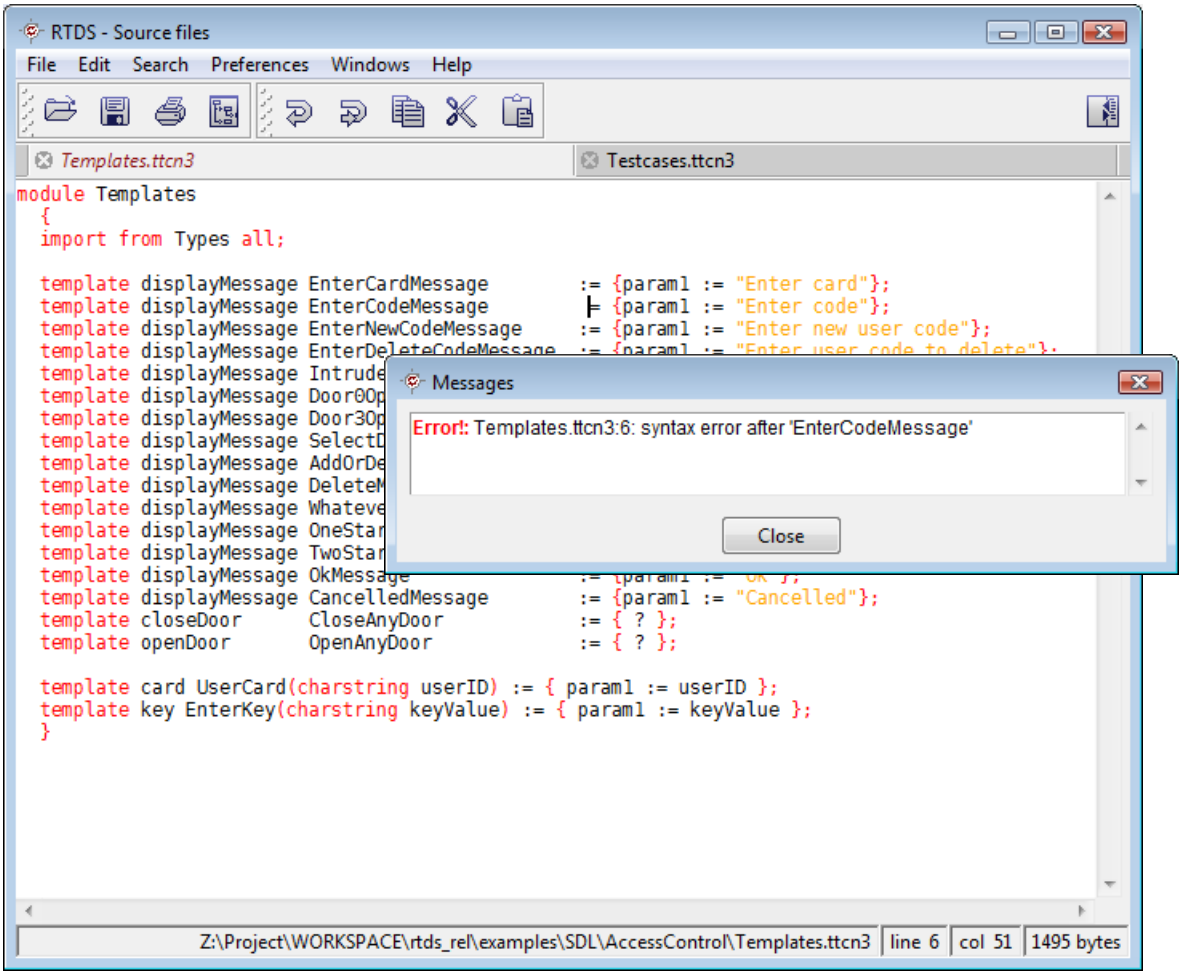
Each TTCN-3 source file should contain a single module, which must have the same name as the file itself. For example, a TTCN-3 file named `AccessControlTest.ttcn3` must contain exactly one TTCN module, named `AccessControlTest`.

Since there is no notion of package in TTCN-3, all modules in a test suite should be put in the same package in RTDS to be able to import each other.

RTDS supports full syntax check of the TTCN-3 files via the menu "File" -> "Check syntax

and semantics..." in the source file editor:




RTDS - Source files
File Edit Search Preferences Windows Help
Templates.ttcn3
Testcases.ttcn3
module Templates
{
import from Types all;
template displayMessage EnterCardMessage := {param1 := "Enter card"};
template displayMessage EnterCodeMessage := {param1 := "Enter code"};
template displayMessage EnterNewCodeMessage := {param1 := "Enter new user code"};
template displayMessage CancelledMessage := {param1 := "Cancelled"};
template closeDoor CloseAnyDoor := { ? };
template openDoor OpenAnyDoor := { ? };
template card UserCard(charstring userID) := { param1 := userID };
template key EnterKey(charstring keyValue) := { param1 := keyValue };
}
Messages
Error!: Templates.ttcn3:6: syntax error after 'EnterCodeMessage'
Close
Z:\Project\WORKSPACE\rtds_rel\examples\SDL\AccessControl\Templates.ttcn3
line 6
col 51
1495 bytes

7.3 - TTCN-3 co-simulation

TTCN-3 test suites in SDL projects can be simulated along with the system they test. To do so, the test itself must be selected and the simulator must be run as described in “Launching the SDL simulator” on page 223. The system under test described in the test will also be run automatically. The test suite will be seen as a process in the SDL simulator, and all features will be available, such as MSC tracing, breakpoints, local variables display, and so on...

There are a few conventions to follow in the test to connect it to the system, and also some restrictions on the TTCN-3 features that can be simulated. These are detailed in the next paragraphs.

7.3.1 Conventions

For TTCN-3 tests to be able to communicate with the system under test, some naming conventions must be followed in the test itself:

- All test cases must run on a component which has a type with the same name as the SUT. So if your system is named `AccessControl`, you must have a component type named `AccessControl` in your test suite, and all test cases must run on it.

- Ports defined in the TTCN-3 component must have the name of the channels connected to the environment in the SUT. So if you have a single channel named `cEnv` in your system connected to the environment, your component type definition must include a port definition with the name `cEnv` for the port. The name for the port type is not significant and can be anything.
- Messages in the SDL system are represented by types in the TTCN-3 test suite. The name for the TTCN-3 type must be the name for the message as declared in the SDL system. For messages with parameters, the TTCN-3 type must be a record, with as many fields as there are parameters in the message. The names for the fields are not significant, but their order is: the first message parameter will be the first field in the type, the second parameter the second field, and so on... The type mapping between SDL and TTCN-3 is described in the reference manual.
  For example, if a message named `close` with a single `Integer` parameter is declared as going out of the system via channel cEnv, the TTCN-3 test suite must define the following type:
  ```
  type record close
    {
    integer param1
    }
  ```
  and the type `close` must be declared as incoming in the port type for the port `cEnv`.

  Messages without parameters are a bit trickier to handle, as there is no empty type in TTCN-3. The convention is then to create an enum type with the name of the message, which has a single possible value with the same name as the type. For example, if a message `refused` with no parameter is declared as incoming via channel `cEnv` in the SDL system, the TTCN-3 test suite must define the following type:
  ```
  type enum refused
    {
    refused
    }
  ```
  and the type `refused` must be declared as outgoing in the port type for the port `cEnv`.
- TTCN-3 and SDL co-simulation also allow test suites to get operator calls from the SDL system via the `getcall/reply` operations in test cases. The signatures declared in the test suite must have the same name as the operators in the SDL system, with the same parameters in the same order and with the same name and type.
  As SDL does not support `in/out` or `out` parameters in operators, they are also not supported in signatures for simulation. All signatures must also be declared as incoming in port types, since there is no way to make synchronous calls to the SDL system. So the `call/getreply` operations are not supported in TTCN-3 test suites for simulation.
  Even if `getcall/reply` operations are made on ports in TTCN-3, the port is actually ignored during simulation: all operator calls can be received on any port, and a `reply` operation will always answer to the last received `getcall` operation. This is due to the fact that operator calls have no connection with channels

in the SDL system, and are therefore not connected to the test in any way. So all operator calls will actually be sent to the test, which will receive it if there is any pending `getcall` operation.
Please note that there is no need to handle operator calls in the test suite: if no `procedure` or `mixed` port type is defined in the test, the operator calls will be handled the "normal" way (ask answer from user or XML-RPC call).

7.3.2 Restrictions

The following features in TTCN-3 test suites are supported for simulation:

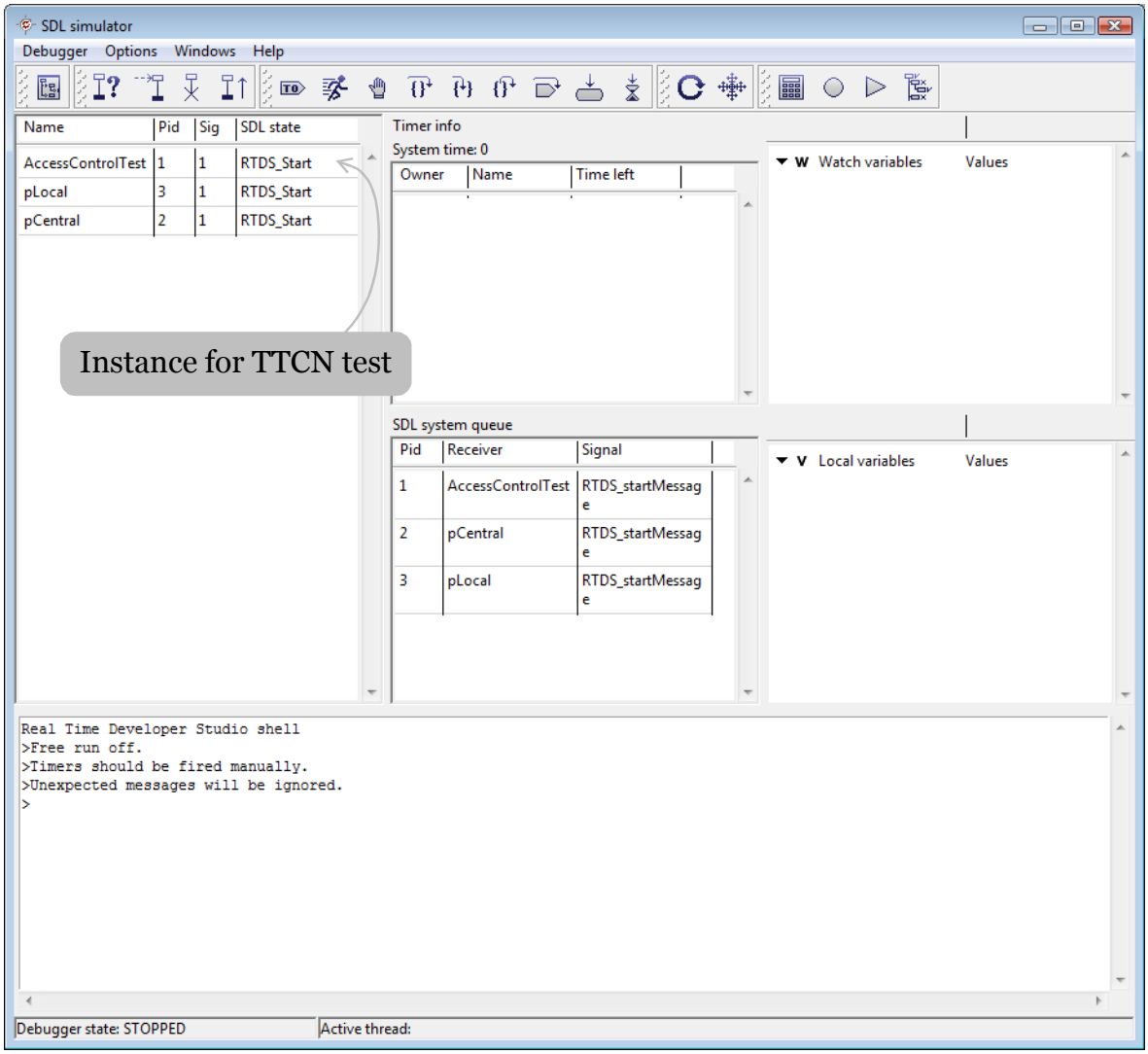
- Modules are supported, but neither module parameters (`modulepar`), nor modules in other languages (`language` clause).
- Imports are supported, but with no restriction or language clause. Imports with restriction clauses are accepted but will import the full module (a warning is issued during the byte-code generation). Imports with a language which is not TTCN-3 will fail.
- Groups are supported, but do nothing.
- The notation `module-name.identifier` for imported identifiers is not yet supported. There must be no ambiguity in imported names.
- Component types are supported, as well as all declarations within them. However, only one component type should be declared, which must have the same name as the SDL system under test. Multiple components are not supported.
- Port types with any type are supported. However, signatures in `procedure` or `mixed` port types can only be declared as incoming. The keyword `all` for incoming or outgoing messages or signatures is also not supported.
  There is also a restriction on message types in ports: two different ports cannot have the same incoming message type. For example:
  ```
  type record my_message { … };
  type port my_port_type_1 { in my_message };
  type port my_port_type_2 { in my_message };
  type component my_component
    {
    port my_port_type_1 my_port_1;
    port my_port_type_2 my_port_2;
    }
  ```
  won't work.
- All basic types are supported except `anytype`, `address`, `default`, and `objid`. Subtypes of basic types with restrictions are also supported, as in:
  `type integer index_type (1 .. 16);`
  The special value `infinity` is only valid in constraints, not as variable value.
  Precision for `bitstring` and `hexstring` types are not yet handled, so operations on these strings won't produce the expected result (concatenation, indexed access, `lengthof`, shifting, ...).
- Among complex types, `record`, `set`, `union`, `enumerated` and arrays are supported. Optional fields in `record` or `set` types are not supported, so the special value `omit` and the predefined function `ispresent` are not supported. In templates, `*` and `?` are also equivalent, and `ifpresent` is meaningless.
  The types `record of` and `set of` are not supported.
  Recursive types are not supported.

Type compatibility is strict, meaning that it is impossible to assign a value to another one if both are not declared with the same type, or compatible subtypes of the same type.

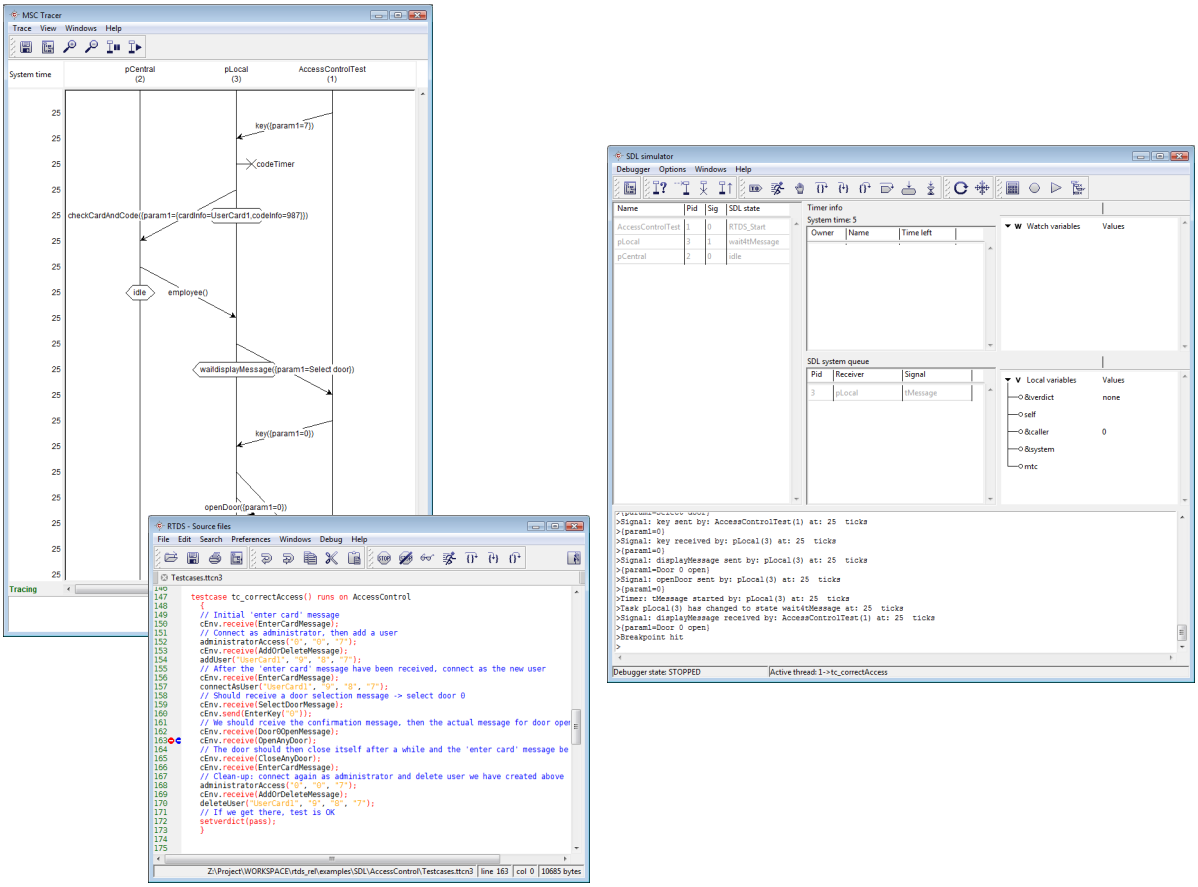
- Signatures are supported, but with no `out` or `inout` parameters. Non-blocking signatures and exceptions are also not supported.
- Templates are supported, including `modifies` clause and template parameters. Template operations `match` and `valueof` are also supported, as well as the special `type-name:{...}` notation.
  However, constraints in templates set via complex values are not supported. For example:
  ```
  type record Point { integer x, integer y };
  type record Segment { Point p1, Point p2 };
  const Point origin := { 0, 0 };
  template Segment origin_segment := { p1 := origin, p2 := ? };
  ```
  will generate an error, as constraint on `p1` in `origin_segment` is specified via the complex value `origin`.
  Constraints on strings specified with `pattern` are not yet supported, as well as the `regexp` predefined function.
  Constraints on non supported types or non-supported features are not supported (optional fields, `subset`, `superset`, `complement`, ...).
  Passing templates as parameters to test cases or functions is also not supported.
- Constants are supported.
- Module control parts are supported.
- Test case invocation is supported, but specifying a time-out won't work.
- Test cases are supported, including test case parameters and `runs on` clause. If present, a `system` clause will be ignored.
- All verdict handling is supported, including automatic verdict setting to `error` on runtime errors in test cases.
- Functions are supported, but not yet altsteps
- Variables are supported with no restriction.
- Timers are supported, as well as all operations on timers, except `read`.
- Port operations are supported, except `stop`, `start`, `check`, `catch`, `call` & `getreply`. A port must always be specified for these operations; specifying `any port` and `all port` instead of a port name is not supported.
- All statements in test cases, functions and control parts are supported: `if`, `while`, `do/while`, `for`...
- Most predefined functions are supported, including all conversion functions.
- Logging is supported but not configurable: today, it will always print a message in the simulator shell.
- Alternatives are supported, including guard conditions on triggers. However, `repeat` is not supported.
- Concurrent testing is not supported, so operations on components (`create`, `running`, `done`, `stop`, `kill`, `killed`, `alive`), `map` and `unmap` predefined functions, and `sender`, `from` & `to` clauses in port operations are not supported.
- `with` clauses are ignored.

7.3.3 Simulation

As said above, running a test suite along with the system it tests is simply done from the project manager by selecting the main test module and running the simulator on it. The simulator window is the standard one and its behavior is exactly the same as the one used for SDL simulation. The test suite will simply appear as a single entry in the list of running instances:



All features in the SDL simulator such as stepping, breakpoints, local variables display or MSC tracing are then available for TTCN code:



As TTCN test cases do not have states, state change symbols in MSC traces are used to display test case verdicts.

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